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Wright-Patterson Air Force Base, Ohio

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ACCURACY AND SPEED OF RESPONSE
TO DIFFERENT VOICE TYPES
IN A COCKPIT VOICE WARNING SYSTEM

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LSSR 89-83

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER LSSR 89-83	2. GOVT ACCESSION NO. A135595	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) ACCURACY AND SPEED OF RESPONSE TO DIFFERENT VOICE TYPES IN A COCKPIT VOICE WARNING SYSTEM		5. TYPE OF REPORT & PERIOD COVERED Master's Thesis
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Jay Freedman, Major, USAF William A. Rumbaugh, Captain, USAF		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS School of Systems and Logistics Air Force Institute of Technology, WPAFB OH 45433		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Department of Communication AFIT/LSH, WPAFB OH 45433		12. REPORT DATE September 1983
		13. NUMBER OF PAGES 179
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Approved for public release: IAW AFR 190-17.

Lynn Wolaver

LYNN E. WOLAVER

Dean for Research and Professional Development

Air Force Institute of Technology (ATC)

Wright-Patterson AFB OH 45433

15 SEP 1983

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Voice warning, voice warning system, bioacoustics, noise, bioengineering, ambient noise, auditory perception, reaction, response, reaction time, male vs female, cockpit warning systems, aircraft alerting systems, VOCRES, voice synthesis

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Thesis Chairman: Rodney C. Byler, Major, USAF

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

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Voice warning systems (VWS) in aircraft cockpits provide a valuable means of warning identification. Improvements in technology have made the VWS a viable addition to aircraft warning systems. This thesis was an experiment to determine the besc voice type (male, female, or neutral machine) for use in a VWS for military aircraft. Different levels of engine background noise, signal to noise ratio of the warning message, and precursor delivery formats were used. The experiment had ten subjects performing a primary tracking task; at random intervals a voice warning was interjected, requiring that the subjects respond by pushing the correct button. The results of this experiment contradict some previous beliefs and findings. The male voice was associated with more accurate responses for voice warning systems in the military aircraft environment. For speed of response the results were more complicated; the male voice was generally more closely associated with faster response times for accurate responses.

LSSR 89-83

ACCURACY AND SPEED OF RESPONSE
TO DIFFERENT VOICE TYPES
IN A COCKPIT VOICE WARNING SYSTEM

A Thesis

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Systems Management

By

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September 1983

Approved for public release;
distribution unlimited

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MASTER OF SCIENCE IN SYSTEMS MANAGEMENT

DATE: 28 September 1983

Rodney C. Byl

COMMITTEE CHAIRMAN

ACKNOWLEDGEMENTS

The authors wish to thank our advisor, Major Rod Byler, for the patience, support and guidance he offered during this thesis effort. Also, we would like to express our appreciation to Major Joe Coleman for the assistance given in the area of statistics. To Tim Anderson, Rich McKinley, and all the people at the Acoustics Lab, our heartfelt "thanx" for all the effort in setting up and carrying out the experiment, and for putting up with us and our "thesis deadlines". Special thanks go to Dr. Guy Shane for his unsolicited research assistance, recommendations and expertise. To Barry Boettcher and the AFIT library staff, thank you for the continuous help as well as for going out of your way on so many occasions. We would like to thank the AFIT staff and faculty in general for making this the experience that it was, and to Pam Marshfield in particular for always being there. Last, but probably most important, we would like to thank our families for doing more than all the others combined: continuing to love us throughout this experience.

Thank you,

Jay and Andy

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CHAPTER I

INTRODUCTION

Purpose

The purpose of this study is to investigate the effects of different voice types (male, female, and machine) on the accuracy and speed of response to a voice warning system. The results of the study will be used in the design, development, and selection of auditory advisory annunciator systems for military aircraft. Therefore, the moderating effects of different background levels of noise, auditory level of the warnings, and warning message formats will be introduced. Parameters that are not specifically listed as variables will maintain constant values typical for military aircraft.

Background

In the last few years the number and variety of warning signals in modern high-performance aircraft have grown steadily. For example, a Federal Aviation Administration (FAA) research project found that "in going from the B-707 to the B-747, the number of alerting signals increased from 188 to 455, or 142 percent" (Berson et al., 1981, p. 2). The F-14A has 47 separate warning and caution signals (Butler et al., 1981). In the military cockpit, this problem is compounded with the addition of combat alerting signals in addition to normal alerts. Especially under high stress combat situations, the audio-visual load on the pilot may reach saturation level, potentially diminishing performance (Thorburn, 1981; Kemerling, et al., 1969).

The primary functions of an alert system include: attracting crew attention, identifying the urgency of the alert, and providing information as to the adequacy of the corrective action (Berson et al., 1981). Ideally, the time required to detect and evaluate alert conditions should be minimized, as well as the time required to begin corrective action, all while maintaining safety of flight and threat avoidance (Boucek et al., 1981).

There are four priorities of alerts that warning systems bring to the attention of the pilot/crew:

> 1. Warning: Emergency operational or aircraft system conditions that require immediate corrective or compensatory crew action;
>
> 2. Caution: Abnormal operational or aircraft system conditions that require immediate crew awareness and require prompt corrective or compensatory crew action;
>
> 3. Advisory: Operational or aircraft system conditions that require crew awareness and may require crew action; and
>
> 4. Information: Operational or aircraft system conditions that require cockpit indications, but not necessarily as part of the integrated warning system (Boucek et al., 1981, p. 3).

Alerting systems that identify these four priorities can be categorized into three basic types: visual, aural, and tactile. Each of these categories can have a "master warning" signal, as well as a separate signal to identify the particular type of alert (Boucek, Veitengruber & Smith, 1977).

As currently implemented, visual systems use different colors, sizes, and intensities of lights to symbolize the priority of the alert (red - warning; yellow - caution; blue, green, or white - advisory). Also, colored lights, bands, and flags are used to further specify the nature of the problem. However, there are no standard visual alert systems, so that similar alerts can specify different problems on different aircraft (Veitengruber, Boucek & Smith, 1977).

A lack of standardization is readily apparent in aural alerts as well. Aural alerts can take the form of bells, horns, chimes, tones, clicks, warblers, and voice, all at varying intensities and frequencies. Each alert can identify a particular problem; but, as with visual alerts, each alert can signify different problems on different aircraft (Veitengruber, Boucek & Smith, 1977).

Tactile systems have been restricted to inducing vibration into the aircraft yoke as an attention getting device (Boucek, Veitengruber & Smith, 1977). Due to the skin's inability to "compete with the eyes or ears in the ability to make fine discriminations or transmit complex information rapidly" the use of tactile systems in aircraft is limited in the amount of information they can provide

(Heard, 1970, p. 31).

The proliferation of alerts, especially auditory alerts, is such that it would be easy for a crewmember to miss or confuse the signal of an emergency condition. To prevent such a situation it has been recommended to reduce the number of aural alerts, or devise a scheme which provides more information for each alert (Pollack & Tecce, 1958; Veitengruber, Boucek & Smith, 1977). One method would be to augment the auditory signal with a visual text display of the specific nature of the problem, such as could be provided on a cathode ray tube (CRT). Another way would be to replace the current multitude of bells, buzzers, beeps, etc. with a voice warning system (VWS). The voice warning could specify the nature of the alert, thereby providing more information and reducing misunderstandings. Williams and Simpson (1976) reported a British Airways paper that argued strongly against the use of nonverbal aural alerts, since they are limited in information content and can be startling or distracting. Voice alerts are recommended for high priority, quick-action alerts. Williams and Simpson also recommended a visual signal, with appropriate color code to distinguish between warnings, cautions, and advisories, as a backup to all auditory signals.

In their pamphlet on recommended practices for flight deck signals, the Society of Automotive Engineers stated that a unique, attention-getting sound (such as a chime, etc.) together with voice alert messages,

> provide a warning superior to that of discrete aural alerts. Therefore, it is strongly recommended that discrete aural alerts not be used in an integrated flight deck alerting system. If, however, familiarity and/or usage should make desirable the use of certain discrete aural alerts, they shall be limited to a maximum of four, and shall meet international standards to be agreed to (1980, p. 2).

A poignant example of the confusion and misunderstandings that can be caused by the proliferation of nonstandardized warnings is the recent incident involving a C-141 crew (A Big Misunderstanding, 1982). While taking off from a CONUS (Continental United States) base, still on takeoff roll, the stall warning horn and the master caution light came on. None of the crewmembers recognized the horn. The copilot initially thought it was an improper configuraton warning horn, until he realized that that horn was only on Boeing 727's; he then decided it was safe to take off, still not knowing what the horn meant on the C-141.

An unknown crewmember said "reject". The aircraft was stopped only 300 feet short of the end of the overrun.

An investigation showed that the horn did, indeed, sound remarkably similar to the improper configuration horn on the 727 (the pilot and jump-seat pilot were both current in the 727; the copilot had been current in the 727 about ten years earlier). In addition, of the 105 crewmembers later asked to identify the seven audible warning signals in the C-141, only 7 crewmembers correctly identified all the signals. A survey also determined that most crews (of the 11 surveyed) ignored the horn when they heard it 5 knots before "go" speed. "Go" speed is the speed at which the pilot is committed to take off, since it would be unsafe to stop.

There are two distinct advantages of a voice warning system. One is that, especially for "heads-up" flying, responses to voice messages are faster than responses to tone signals (Kemmerling et al., 1969) or visual signals (Boucek, Veitengruber & Smith, 1977; Davis, Rundle & Stockton, 1981; Cooper, 1977). "Heads-up" flying refers to the current practice of flying in which the pilot's attention is focused out of the cockpit. To affect this technique, as much information as possible (airspeed, altitude, direction, etc.) is presented in heads-up displays (HUD's) so that the pilot need not focus his attention down into the cockpit (Butler et al., 1981). Davis, Rundle and Stockton (1981) noted that several mid-air collisions have been caused by pilots trying to perform system checks while flying in close formation.

The second advantage is that specific voice alert information gives the pilot the option of evaluating the alert and responding immediately, or of delaying his response, secure "in the knowledge that it would be safe to do so" (Davis, Rundle & Stockton, 1981, p. vii). Thus, if his current task is of extraordinary priority (threat avoidance), he need not neglect that task in order to identify and evaluate the alert, probably with unpleasant results.

History

The Air Force began experimenting with voice warning systems (VWS) in 1961, when a successful audio tape system was introduced into the entire fleet of B-58 Hustlers (Davis, Rundle & Stockton, 1981; Thorburn, 1971). Subsequent questioning by the Directorate of Aerospace Safety showed that 91 of 97 pilots felt that the VWS contributed to flight safety, and all but two wanted the VWS in the FB-111 if they were assigned to that aircraft (cited in Kemmerling et al., 1969).

In 1963, the Tactical Air Command performed a series of tests using a VWS in the F-100F aircraft. The results showed a significant improvement in pilot reaction time, especially under heavy loading or stress (Thorburn, 1971). In fact, the improvement factor was 42-to-1 during the highest workload phase of the test (Davis, Rundle & Stockton, 1981). Cooper (1977) stated that the Air Force found a six to nine second improvement in warning recognition through the use of a VWS. Favorable results were also found in tests at the Naval Air Test Center in 1963 (Kemmerling et al., 1969).

The results of the 1963 VWS tests prompted the Air Force Inspector General for Air Safety (AFIAS) to state that his office "..firmly supports the installation of voice warning systems in all high-performance aircraft wherein there is no flight engineer position" (cited in Thorburn, 1971, p. 3). The AFIAS letter cited several incidents in which the VWS had prevented a serious accident (Kemmerling et al., 1969).

The Army also became heavily involved in testing the use of VWS. In 1968, a study at the Aberdeen Proving Ground identified the characteristics of a VWS for installation into six Army aircraft, including five helicopters (Brown, Bertone & Obermayer, 1968).

Despite the clear advantages of voice warning systems, implementation in aircraft has been slow. Lea (1981) noted:

> Listening to machines may be difficult in the presence of auditory noises or interfering conversations. The spoken utterance is not readily sustained in time, such as are lights, displays, or manual knob positions. Speech generated by machines may not be attended to, or understood by, the human listener, and if not heard when initially spoken, it will not be continuously available for later scrutiny. If the machine does not speak intelligibly and with good voice quality, these problems may be particularly accented (p. 3).

Other objections cited by Pollock (1958) include such factors as cost, weight, and reliability. However, changes in technology have overcome these objections. The necessary hardware and circuitry now are quite compact, with significant improvements in reliability. For example, SCI Systems, Inc., manufactures a voice warning system for the F-14 aircraft that occupyies 476 cubic inches and weighs 11 pounds; Rockwell International manufactures a system called FPA-80, Flight Path Advisory System, which occupies 93.5 cubic inches and weighs only 3 pounds; McDonnell-Douglas manufactures a voice warning generator for aircraft that occupies 90 cubic inches and weighs 4 pounds (Butler et al., 1981).

An additional reason for the delay in implementation may have been air tactics in the Vietnam conflict. It was common for missions to have a large number of aircraft attacking a single target. Such missions achieved coordination by everyone using the same radio frequency. The addition of a VWS was one more voice that pilots did not want to hear (Davis, Rundle & Stockton, 1981).

Types of Speech Synthesis

Improvements in speech synthesis technology have alleviated early concerns about the practicality and reliability of voice warning systems. Speech generation requires that the phonetic characteristics of words or parts of words be stored in a digital form so that they can be retrieved and reproduced by a speech synthesis device. Werkowitz (1980) and Davis, Rundle and Stockton (1981) note that three current methods of speech coding and synthesis are waveform coding, linear-predictive coding (LPC), and phoneme synthesis.

Waveform coding is a technique in which speech is sampled and the digitized samples are stored in Read Only Memory (ROM). The data are compressed so that an intelligible signal is produced when the coded speech data are processed by a waveform synthesizer which may contain a digital/analog converter. Waveform coding generates a very high quality voice signal but requires a relatively large amount of computer memory.

Linear predictive coding analyzes speech to determine pitch, amplitude, and frequency characteristics as a function of time. These characteristics are then stored in ROM. Reproduction of the voice is performed by using a multi-stage digital filter, a pulse generator, and a random noise generator. The quality of the voice that is generated is not as good as in waveform coding, but because this method stores less information about the voice, less computer memory is required.

Phoneme synthesis forms words or phrases by connecting basic speech sounds (phonemes). Phoneme synthesis requires very little ROM. The process involves encoding the basic speech sounds only, and producing intelligible speech by sequentially reproducing different combinatins of the stored data. The English Language can be synthesized by using between 45 and 60 phonemes or phoneme variations (Butler et al., 1981). One manufacturer stated that 150 bits per second can generate continuous speech. However, the speech has a very unnatural, mechanical sound (Werkowitz, 1980; Davis, Rundle & Stockton, 1981).

Problem Statement

Increasing aircraft complexity and pilot/crew workloads have increased the importance of timely and appropriate reactions to warning signals or messages. There are favorable experimental results that have shown that voice warning systems decrease reaction times significantly without severe impact on the primary task of flying (Veitengruber, Boucek & Smith, 1977). The problem is that there are insufficient data to indicate whether a male, female, or machine voice should be used.

Justification

In the Aircraft Alerting Systems Criteria Study, Volume I, the need for data collection on certain factors affecting "Verbal Auditory Caution and Warning Signals" is identified. Voice type was rated "Highest priority data" (Veitengruber, Boucek & Smith, 1977, p. 80).

Though several surveys among pilots indicate a preference for the female voice (Berson et al., 1981), no study could be found which measured accuracy and speed of response as a function of the type of voice. There is a need for an empirical study to determine whether the expressed preference is justified, or whether another voice type might be better in terms of alert response.

Research Question

This experiment will investigate whether there is a significant difference in the accuracy and speed of response to different voice types under various background noise levels, signal-to-noise ratios, and warning formats in a simulated military aircraft cockpit noise environment.

Scope and Limitations

The research will be limited to investigations of the following differences:

1. Voice types: male, female, and machine;
2. Warning format: tone precursor, voice precursor, and repeated warning;
3. Background noise: 105 db and 115 db; and
4. Signal-to-noise ratio: 0, 5, and 10 db above headphone conversation noise.

Speed of response will consider only accurate responses.

Assumptions

A voice warning in a cockpit environment will normally be given to a crewmember who is proficient at his primary task (flying the aircraft) and capable of performing a secondary task (responding to the alert). Subjects for this experiment were specifically trained in the primary and secondary tasks to assure a common level of proficiency. This was done to ensure sufficient task knowledge to prevent any training effects from counfounding the data. Also, task proficiency was considered more critical than job title; subjects were therefore not necessarily crewmembers, but were personnel who have passed the rigorous hearing and training requirements necessary for this experiment. Personnel at the Biological Acoustics Branch of the Aerospace Medical Research Laboratory at Wright-Patterson Air Force Base, Ohio stated that "previous data indicates that there is a high correlation between the reactions of the pilot population and the general population" (Anderson & McKinley, 1983).

It was further assumed that most warnings require a manual reponse by the crewmember, such as flipping a lever, pushing a button, turning a knob, etc. The secondary task in this experiment therefore required a manual response.

Preview

Chapter II contains a literature review focusing on the response to different voice types in aircraft alerting systems. Methodology is discussed in Chapter III, including background information on the moderating variables. The equipment used and experimental design are presented, followed by an explanation of the methods of data reduction. The results and analysis of the data are listed in Chapter IV. Conclusions are presented in Chapter V, and a general discussion and recommendations are offered in Chapter VI.

CHAPTER II

LITERATURE REVIEW

There is a marked scarcity of literature comparing voice types, especially regarding voice warning systems. Only two studies were found that address differences in reactions to male and female voices.

In 1948, Black and Graybiel investigated the effect of heard stimuli on spoken responses. Research showed that the subjects reacted to different voice types with reponses of different intensities. The subjects responded in a louder voice to the female voice as compared with their response to a male voice. However, the results may be misleading because all the subjects were male. In addition, Black and Graybiel noted that the observed differences might be due to "non-identical intensity levels in the stimulus materials" (1948, p. 1). In the other study comparing voice types, Kerce (1979, cited in Berson et al., 1981) tested the relative intelligibility of different voice types. In her study, Kerce measured intelligibility by having subjects record verbatim reproductions of verbal messages. Results indicated that the female voice was more intelligible than the male voice and that both were preferable to a synthetic "machine" voice. Kerce recommended that although the female voice will generally be more intelligible than the male voice, voice characteristic selection should be based on a spectral analysis of the voice model and ambient noise environment in order to achieve the best possible results (Berson et al., 1981).

In the analysis of VWS for implementation in Army aircraft, Brown, Bertone and Obermayer (1968) recommended that a female voice be used. The recommendation was based on vehicle noise characteristics (frequencies of engine noise) as well as pilot reports which claim that the female voice would be more distinctive and therefore more easily heard over other communications.

That the female voice is less common in voice communications and thus more distinctive is a prevalent argument for using the female voice (Berson et al., 1981). Davis, Rundle and Stockton (1981) recommended a female voice both because of its higher register and its distinctiveness in communications. They stated that despite more and more female voices heard over the radio, the majority of voices are still male.

Butler et al. (1981) acknowledged the supposed "differentness" of the female voice as the reason that that voice was used in early voice warning systems. However, they suggested that the current trend toward using women as controllers, both military and civilian, effectively counters that argument. Butler et al. also suggested that there may be some pilots who do not want to hear a female voice while in action.

A voice that could be more distinctive than the female voice is a synthesized neutral or machine voice. Such a voice would be more unlike normal communications than a human voice and thus even more distinctive. The voice could be easily generated by any of the voice synthesizers described in Chapter I. Simpson and Williams (1980) stated that synthesized speech could be used both to attract attention and to perform the information transmission function.

Factors affecting the intelligibility of a voice include its intensity and frequency. Nemeyer (1981) noted that the softest noise the ear can hear is caused by pressure changes on the order of 0.00002 Newtons per square meter. The frequency range to which the ear is sensitive ranges from 30 hertz to 18 kilohertz in young people, and from about 100 hertz to 10 kilohertz in older people (Radio, 1974). Muller (1975) stated that the base frequency of female voices is from 210 to 240 hertz and that the base frequency of male voices is from 130 to 140 hertz. Brown, Bertone and Obermayer (1968) noted the same difference in voice frequencies in their analysis of VWS for the Army. They further stated that the distinctiveness of the female voice may be related to its higher base frequency.

Perceived loudness of sound is determined by a combination of sound frequency and intensity. That is, for two tones of equal intensity, the one with the higher frequency will be perceived as louder (Berson et al., 1981; Fletcher, 1953). Besides contributing to perceived loudness, intensity greatly affects intelligibility (Black & Graybiel, 1948). However, intensity is not meaningful in itself; rather, it is the intensity relative to the environment noise level that affects perceived loudness and intelligibility.

Davis, Rundle and Stockton (1981) suggested that the intensity of the alert in a audible warning system be preset and not subject to pilot control. They recommended a level of 105 db as high enough to attract attention but not so loud as to be startling. Other researchers have suggested varying the alert in a range of 5 to 15 db above ambient noise (Berson et al., 1981; Brown, Bertone & Obermayer, 1968; Boucek, Veitengruber & Smith, 1977). However, it should be noted that the consensus among pilots in a 1977 survey was that most aural alerts in commercial aircraft were too loud (Cooper, 1977).

Studies about implementing a VWS in particular aircraft (Brown, Bertone & Obermayer, 1968; Butler et al., 1981; Davis, Rundle & Stockton, 1981) recommended using a female voice due to its perceived distinctiveness as well as the relative infrequency of female voices in radio communications. However, distinctiveness and intelligibility of the voice are assets in the cockpit only to the extent that the pilot/crewmember will be able to respond correctly and quickly to a warning signal. The authors of this thesis were unable to find an empirical study of response to different voice types in a voice warning system. Thus, despite the widely accepted perception that the female voice is more distinctive in a cockpit environment, there is a need to determine, by empirical tests, the voice type to which people respond most accurately and quickly.

CHAPTER III

METHODOLOGY

The chapter on Methodology is divided into four sections. Section one will discuss the variables to be examined. Section two will explain the equipment used to perform the experiment and record the data. Section three will explain the experimental design. Section four will review the data reduction and analysis techniques used to evaluate the results.

Variables to be Examined

Dependent variables are accuracy and speed of response. Independent variables are male, female, and machine voice types. Moderating variables are background noise, masking by background conversation, and precursors to the warning.

Accuracy of Response

The required response to each warning is to push the correct button, as specified in each particular warning. Accuracy is measured as a ratio of the number of correct responses to the total number of required responses.

Reaction vs. Response

Reaction time is the time it takes an observer to detect a signal and react to it when that is the only task that he/she is required to do. Time measurements which record reaction time are "not contaminated by other variables, such as workload or distracting movements, and are therefore the optimum response unit" (Boucek, Veitengruber & Smith, 1977, p. 2).

Response time, when dealing with experiments conducted in a real or simulated cockpit environment, is a measure of the time to respond to a signal when that is not the only thing an observer is doing. Actually, the response is often a secondary task accomplished simultaneously with the primary task (i.e., flying the airplane). Reaction time can give "an indication as to the direction of the results for response time, but it is not necessarily a direct measurement" (Boucek, Veitengruber & Smith, 1977, p. 2).

To make the results of this experiment more relevant to the cockpit environment in military aircraft, subjects were given simultaneous tasks. Tracking a blinking light was their primary task and responding to the voice warning was their secondary task. Response time is defined as the time from the beginning of the warning message to the time it takes to complete the appropriate response.

Voice Types

Male and female voice warnings were recorded in the anechoic chamber of the Biological Acoustics Laboratory at Wright-Patterson Air Force Base, Ohio. The recorded voices were subsequently digitized for reproduction. The machine voice was produced by removing the variation in the frequency of the recorded male speaker.

Background Noise

Voice intelligibility varies with different levels of background noise. Kerce (1979, as noted in Berson et al., 1981) used a background noise level of 76 db in her investigation of voice intelligibility. In an experiment investigating the effects of precursors, Simpson and Williams (1980) used a cockpit noise level which measured 75 db average. Many commercial aircraft have an ambient noise level in the cockpit around 76 db. The noise levels in military aircraft are normally higher. For example, inflight noise levels in the F-16 fighter range from 92 to 112 db (Hille, 1979). Under the presumption that warning and response times are most critical when the pilot/crewmember is under high task-loading and high noise conditions, background engine noise levels of 105 db and 115 db were used to allow the results of this experiment to be more applicable to the military cockpit environment.

Masking

Masking, in voice communications, occurs when a person cannot distinguish between a particular signal (the voice) and background noise. Masking can be complete or partial. In partial masking, enough of the signal may get through so that it is still intelligible.

Berson et al. (1981) noted that with a background noise level of about 30 db, it requires a smaller incremental increase in amplitude to make lower frequencies discernible than to make higher frequencies discernible over the background noise, in the base frequency range of the human voice. The male voice has a base frequency around 130 hertz, while the average base frequency of the female voice is about 210 hertz (Muller,1975). Thus, although several sources (Berson et al., 1981; Boucek, Veitengruber & Smith, 1977; Brown, Bertone & Obermayer, 1968; Thorburn, 1971) cite preference for the female voice due to its distinctiveness, the male voice may be discernible at a lower signal-to-noise ratio than the female voice.

To investigate the effects of masking, the voice warning was fed into the subjects' earphones at three signal-to-noise (S/N) levels: 0, 5, and 10 decibels above the headphone conversation level.

Precursor

When a voice alert is not preceded by an attention getting sound, it is possible for the pilot/crewmember to miss the first few syllables of the voice message. A 1979 Douglas Aircraft Company survey (Berson et al., 1981) and a study by Boucek et al. (1981) both found that pilots overwhelmingly prefer an aural precursor to the voice warning. The difference between those preferring a tone precursor to those preferring voice (e.g., "Warning" or "Caution") was not significant (Boucek et al., 1981).

The voice warnings in the baseline Voice Synthesis System (VSS) for the Navy's F-14 Tomcat precedes voice alerts by the word "Warning" or "Caution" (Butler et al., 1981). The Voice Message System on the Air Force's F-15 Eagle uses the same format (Davis, Rundle & Stockton, 1981). Brown, Bertone and Obermayer (1968) recommended that the voice alert be preceeded by an aural tone for the Army. Kemmerling et al. (1969), however, warned that the aural precursor might actually be a nuisance or distraction. Despite this, the 1974 edition of MIL-STD-1472B, *Human Engineerng Design Criteria for Military Systems, Equipment, and Facilities*, specifically required the use of a nonspeech alerting signal prior to a voice warning (Simpson & Williams, 1980).

Until 1980, there was no experimental evidence to support those recommendations. Simpson and Williams (1980) performed an experiment to test whether a tone or voice precursor elicited the shorter response time. They found that the effect of a tone before a voice warning was to actually lengthen the response time (i.e. subjects reacted more slowly). When the voice warning was lengthened with another word, however, the response time did not increase.

Studies by Simpson, Hart, and Williams between 1975 and 1980 showed that commercial airline pilots reacted faster to messages in full sentence format than to messages using key words or short phrases (Davis, Rundle & Stockton, 1981), indicating that context increases the intelligibility and/or decreases response time. However, when the question was asked of military pilots whether they would prefer short, military-style messages as opposed to full sentences, the response was unanimously in favor of the short, military-style messages (Davis, Rundle & Stockton, 1981)

A 1963 Navy test of a voice system installed in the VA-3B aircraft indicated that response times to warnings delivered once were slower than to those warnings using a "double call-out" (warning repeated). The difference in resonse time was not significant. The pilots indicated that they preferred the double call-out (Lilleboe, 1963, p. 11).

To investigate the confounding effect of precursors on voice warning response times, three delivery styles were used: repeated message (double call-out), a tone precursor, and an aural ("Warning") precursor. The repeated message was not preceded by any other alert, since the message acted as its own precursor. The tone precursor had a frequency of 500 hertz and sounded for 0.3 seconds; it was delivered at the same amplitude as the voice warning (0, 5, and 10 db above the ambient conversation over the headsets).

Equipment Used

The experiment was conducted using the Voice Communication Research and Evaluation System (VOCRES), located in the Biodynamics and Bioengineering Division of the Aerospace Medical Research Laboratory at Wright-Patterson AFB, Ohio. The VOCRES was developed "to provide the capability for comprehensive research, test and evaluation activities in the voice communications effectiveness arena" (McKinley, 1980, p. 2). Ten consoles are located in a large reverberation chamber; the chamber has a programmable sound source capable of emulating aircraft engine noise as heard in the cockpit. Each console is equipped with a standard AIC-25 aircraft intercommunication system. Voice communication is affected through standard headsets in HGU-26/P flight helmets.

Each console has two panels: a display-response unit and a keyboard for communication performance task response (see figure 1). Both panels are connected to an on-line computer data collection and analysis system. The Central Processing Unit (CPU) for this system is the Hewlett Packard (HP) 9845T computer. The display/response unit was used for the primary tracking task, while the keyboard was used to measure the secondary warning response task. For a more detailed description of the VOCRES facilities, see Appendix A.

Digitized voices were generated by the Texas Instruments (TI) 5220 Speech Synthesis chip, using the linear predictive coding (LPC) method. Voice warnings and background voice communications were heard through the headsets in the helmets. Engine noise was generated via the programmable sound source, through the loudspeakers lining the room.

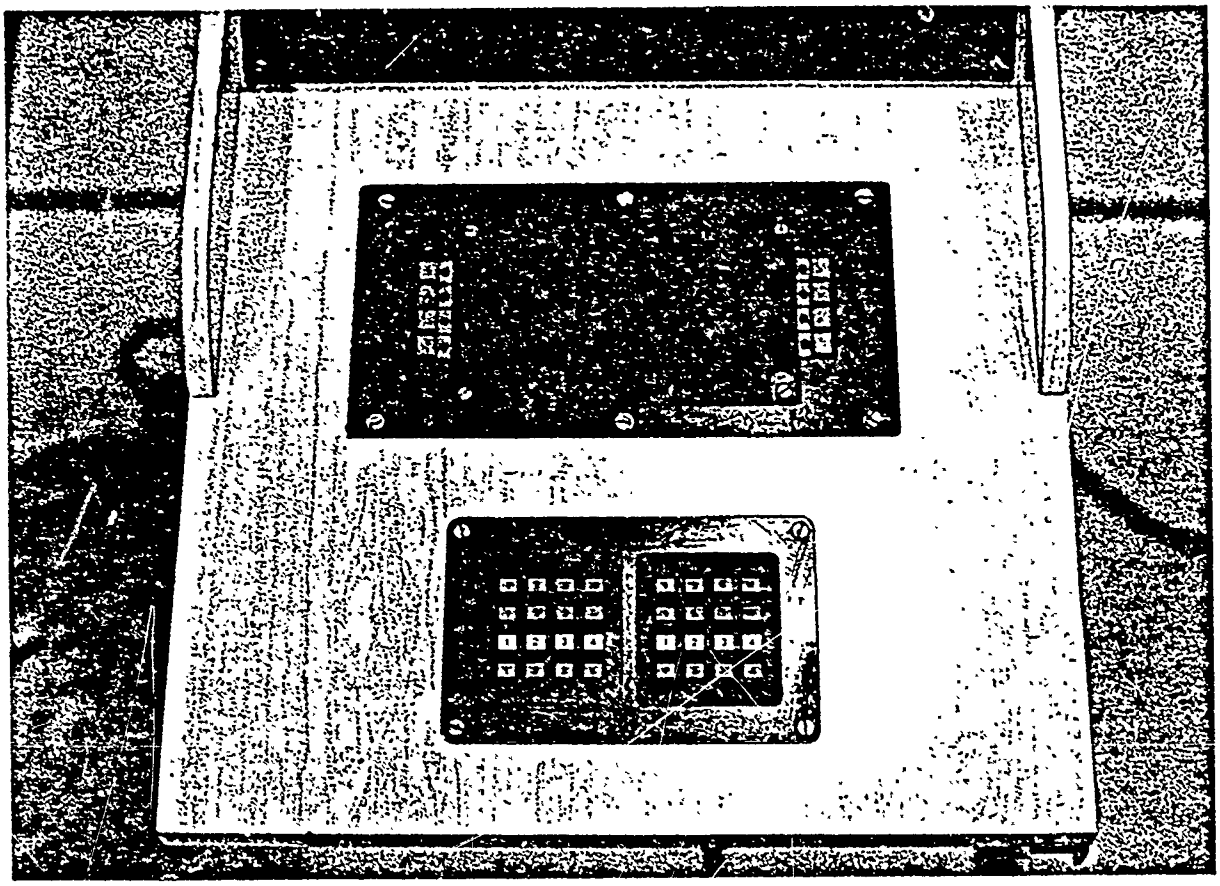

Figure 1. *Console in VOCRES Facility*

The computer facilities recorded the response time for each warning, and kept a record of the sequence of the warnings. Time was measured using a Z80 CTC microprocessing chip, which measures to an accuracy of 3 microseconds.

Delegation of responsibilities for calibration and maintenance of the equipment, together with details of the experimental procedures for VOCRES personnel, are contained in Appendix B1 (Test Plan).

Experimental Design

Primary Task

The primary tracking task was performed on the upper panel. An asterisk was displayed on the screen, and the subject had to "track" the asterisk by touching the button closest to the symbol. There were eight buttons, four on each side. The subjects had to hit the appropriate button each time the asterisk appeared, or it was recorded as an error in the primary task. The asterisk was displayed every 0.6 second throughout the test, which lasted about 35 minutes per run. To ensure that subjects performed as well as possible throughout each session, they were advised that they would not be used in further tests if their accuracy fell below a certain level. Since the pay bonus was only effective if they completed all the sessions, there was a built-in incentive to do well. Trial runs conducted prior to the actual experiment established an acceptable level of accuracy for this task.

To increase the primary task loading and simulate a busy cockpit environment, background tapes of aircrew conversations and radio transmissions were played through the subjects' headsets throughout each run.

Secondary Task

The secondary task, which was to respond to the voice warning, was accomplished on the lower panel of the console. The lower panel is made up of two keypads, containing sixteen buttons each. The pads are set side by side, thus producing an arrangement of four rows and eight columns. Each row is a different color (red, grey, white, blue). The columns are numbered "1" through "4" on each keypad. The warning directed the subject specifically which button to push, identifying it by left-or-right, color and number.

Experimental Procedure

The experiment was of a balanced design. For each session, one voice type, precursor format, engine background noise, and signal-to-noise ratio were used. Each combination was accommodated once; that means there were 3 (voice types) * 3 (precursor formats) * 2 (engine background noises) * 3 (S/N ratios) = 54 trials. The possible combinations are depicted in Figure 2.

Pre-cursor:	REPEATED						TONE						VOICE					
Backgrd Noise:	105			115			105			115			105			115		
S/N Ratio:	0	5	10	0	5	10	0	5	10	0	5	10	0	5	10	0	5	10
MALE	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
FEMALE	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
MACHINE	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

Figure 2. *Treatment Combinations*

In order to minimize the effect of any possible learning curve, the combination of parameters and the original order of the runs were determined using random methods of selection. The random order thus determined is reflected in the run parameter code. The order of the runs was then adjusted only when necessary to remain within USAF standards for noise exposure, as established by AFR 161-35, *Hazardous Noise Exposure*, and AFR 169-3, *Use of Human Subjects in RDT&E*. The final sequence is indicated by the run sequence number (see Experimental Design Sequence, Appendix B2) .

Ten subjects were each seated at a console in the VOCRES facility, wearing the flight helmet. Throughout the session, they performed the primary tracking task, which required a continuous level of participation. Warnings were interjected at random times through the headsets in the helmet. For the response to be counted as accurate, the subjects had to push the correct button within three seconds after the end of the warning. The primary task did not stop when warnings were interjected, but continued to require attention. Detailed instructions to the subjects are contained in Appendix B3.

Subjects

To ensure that the results of experiments at the VOCRES laboratory were as free as possible from the contaminating effects of having someone learn the task while undergoing the experiment, subjects used in VOCRES tests were screened by personnel at the lab. Each subject was tested for any signs of hearing loss. Before being allowed to participate in the experiment, subjects underwent about twenty hours of training, to ensure proficiency at the task. Personnel at the lab have found that in speed of response tests, subjects with inadequate training do not contribute useable data due to the learning effect in this type of experiment (Anderson & McKinley, 1983). Personnel at the lab maintain a current list of available subjects with no appreciable hearing loss who are familiar with VOCRES procedures.

Subjects who participated in this experiment were paid on an hourly basis. The pay scale had a built in incentive, in that the hourly rate was increased if the subjects were present for all sessions in the experiment and provided useable data. This ensured consistency by using the same subjects throughout all 54 runs.

Of the ten subjects who participated in this experiment, four were male and six were female. All ten have been previously employed as subjects either full or part time at the VOCRES facility. The ages range from 20 to 40 years old.

<u>Other Considerations</u>

To reduce spatial disorientation, the subjects were allowed to choose their seats during the training sessions. Once they had chosen a seat, they maintained that seat throughout all 54 runs.

To reduce any possible bias due to the physical location of the response buttons on the lower panel, all 32 possible warnings were called out during each session. The order of the callings was set by a random number generator, and was changed for each new session. By requiring that all 32 warnings be called during each run, the effects of certain word combinations (e.g. "right white...", "...blue two", "right red...", etc.) were balanced for the experiment.

To ensure that the subject did not sit and wait for a rhythmic sequence of warnings, the time between warnings was also set by a random number generator, with the following two constraints: no closer together than 10 seconds, no further apart than 5 minutes. The sequence was initially generated about a normal dstribution with a mean of one minute, establishing approximately a half-hour core session time.

"End effects" are aberrations of responses early in the session (just getting warmed up) and at the end of sessions (know it will end soon, so mind is not on experiment). To reduce end effects, an additional three-minute segment was added at the beginning of the session, and a two minute segment was added at the end; responses during these end segments were not included in the analysis. Subjects were not aware of the addition of these end-segments nor that the results of the two end-segments were not recorded.

To ensure that all 32 buttons were nit in the core session time, warnings were generated using the same random number algorithm for the two end segments as was used for the core segment. Thus some buttons were repeated during the session--once during the core session, and possibly one or more times during the end segments. This also ensured that no subject could, like a good poker player, "count cards" and anticipate which buttons would most likely be called near the end of the session.

To generate a baseline for accuracy of the primary task, one more constraint was imposed: after the sequence and time intervals for the secondary task were generated, the longest time between warnings was set to equal five minutes. This did not affect any other time in the session. The five minute time was used each session to assess uninterrupted (baseline) accuracy for the primary task. Since the time at which this 5-minute period occurred varied from session to session, subjects were not able to anticipate the lull in warning activity. Since the original constraint on the random number generator was set at a 5-minute maximum, expanding the longest lull to equal five minutes changed the length of each session by different amounts, thus reducing even further possible end-effects. Including end segments, sessions were designed to last between 30 and 40 minutes, with no two sessions having the same length.

The primary tracking task accuracy was the accuracy of the primary task during each run, excluding the five minute baseline period. The normalized primary task accuracy is herein defined as the ratio of the primary tracking task accuracy divided by the baseline accuracy. This ratio provided a measure of change in performance caused by the addition of the secondary task.

Data Reduction and Analysis

Information recorded for each trial included the run parameter code, the date and time when the test started, and the run parameters (voice type, background noise, S/N ratio, and precursor format) used for that particular trial. Primary and secondary task information was recorded for each subject. For the primary task, the number of stimuli and number of correct responses were recorded both throughout each run and for the baseline period. For the warning response task, each stimulus and its response time were recorded. Responses for the first three minutes and last two minutes of each test were not recorded. File conventions are listed in Appendix D1. Subject and group mean performance data are listed in Appendix D2 and Appendix D3.

A Multiple Analysis of Variance (MANOVA) was used to investigate the effects of different voice types on the accuracy and speed of response to the warning stimuli. Before trying to determine the effects of different voice types, the data were analyzed to validate the experimental design. Results from the validation steps helped determine the final model design for the MANOVA. Statistical manipulations were performed using author-generated programs (see Appendix C) and subprograms from the Statistical Package for the Social Sciences (SPSS), version

9 (Nie et al., 1975; Hull & Nie, 1981).

Design Validation:

Step 1:

An author-generated program was used to create new data files from the raw data files. The four new data files created were used as databases for different measurements; one file contained individual data points, one file listed individual subject performance within each run, one file listed mean group performance for each run, and one file combined individual data point, subject, and group mean information.

Step 2:

A summary of all measurements was obtained using the CONDESCRIPTIVE and FREQUENCIES subprograms of the SPSS to validate that all treatments occurred the correct number of times and that the design was balanced. Additionally, statistics from this summary were used to validate the results of the author-generated programs.

Step 3:

A grouped t-test for both accuracy and response time was performed within each of the 54 runs. The responses to the first one-third warnings (stimuli number 1 thru 11) were compared with those of the last one-third (stimuli number 22 through 32). These tests were used to check for the presence of either learning effect or fatigue within each run.

Step 4:

A one-way Analysis of Variance (ANOVA) and regression were performed independently on both accuracy and response time, using the run sequence number as the treatment. These measures were used to check for the presence of learning effect or fatigue across the runs. Additionally, a regression of run sequence number on the normalized primary tracking task performance was calculated to supply information on the extent to which subjects acclimated themselves to the interjection of warnings over the course of the experiment.

Effects on Accuracy and Speed

The MANOVA was performed next, using accuracy of response and speed of response as the criterion (dependent) variables. Treatments included the voice types, precursor, background level, and S/N ratio, with blocking on the individual subjects. Two-way, three-way, and four-way interactions of the treatments (except individual subjects) were included in the MANOVA design. The run sequence number and normalized primary task performance were included as covariates (Hull & Nie, 1981). The Null Hypothesis is that there was no significant difference in speed of response or accuracy of response among the several treatments. If the Null Hypothesis was not rejected, then the conclusion would be that accuracy and speed of response are not affected by different voice types in voice warning systems, within the limitations of our experiment. If the

Null Hypothesis was rejected, then we could say speed and/or accuracy of response were affected by some or all of the variables examined in this experiment.

A one-way ANOVA was then performed independently on the accuracy and speed of reaction, using those treatments identified in the MANOVA as having a significant effect. The ANOVA employed the Scheffe Method of Multiple Comparisons (Neter & Wasserman, 1974) to identify the groupings of the treatments. The ANOVA was also used to indicate the relative increase or decrease in performance explained by the different treatments. Due to the interaction of the variables, the ANOVA could not be interpreted independently, but was only useful in helping to interpret the results of the MANOVA.

CHAPTER IV

RESULTS AND ANALYSIS

This chapter is divided into four sections. Section one will describe the conduct of the experiment. Section two will present the data results. Section three will discuss the validation of the experimental design, as mentioned in section four of Chapter III. Section four will analyze the effects of the treatments on the accuracy and speed of response.

Conduct of the Experiment

The experiment took place in the VOCRES facility between 14 June 83 and 6 July 83. There were four runs each day, all in the morning. Subjects were given a half-hour break between runs.

Voice Warnings

After the recordings of professional announcers were completed, the warnings were digitized for LPC generation. The mean length for all thirty-two warnings for the male voice was 1.1406 seconds, with a standard deviation of .0538 seconds; for the female voice the mean length was 1.0204 seconds, with a standard deviation of .0485 seconds; for the machine voice the mean length was 1.1262 seconds, with a standard deviation of .0489 seconds.

Training

Training and practice runs were accomplished two weeks before the beginning of the experiment. During the training and practice runs, the baseline tracking accuracy was used for two purposes: setting the primary task frequency and eliminating subjects with poor performance. Originally, the asterisks were generated on the screen each 0.7 seconds; the mean reaction time to the primary task was about 0.6 seconds, and the mean primary task accuracy was about 97%. Two subjects, whose performance fell consistently below 75%, were replaced. The primary task interval was then decreased as the subjects' proficiency increased, and the asterisk was generated each 0.6 seconds. Mean primary task accuracy then fell, but still remained above 90%. One subject, whose perfomance fell consistently below 75%, was replaced. As the subjects became more proficient, the secondary "warning" task was added to their training, using random mixes of the variables. Toward the end of their training, the subjects underwent the same conditions they would encounter in the actual experiment. Subjects were not told when the last "practice run" occurred and when the first "real run" began.

Data Points

Fifty-four runs were completed, representing the balanced application of all combinations of treatments to each subject. The same ten subjects participated in all of the runs. The thirty-two "warning" stimuli were all administered during each session. Thus the number of stimuli recorded totaled 17,280.

Data Transfer

A problem in data transfer occurred in that the Hewlett Packard (HP) 9845T, on which the raw data had been recorded, was unable to transfer the data directly to the CDC Cyber 750, on which the SPSS MANOVA program was implemented. To overcome that problem, the authors attached an Apple IIe microcomputer to the serial output port of the HP. The HP was then programmed to generate line numbers and send the data out through its serial port, thinking it was only sending ASCII-standard characters to a printer. The Apple IIe accepted the raw data and saved it in the form of a BASIC file. For each run, the data was then transformed into a TEXT file within the Apple IIe; in that form it could be transferred via a MODEM to the CYBER computer. File conventions used in the transfer of data are outlined in Appendix D1.

Results

For the primary tracking task, the mean baseline accuracy throughout all 54 runs was 89.0%, with a standard deviation of 9.8%. The maximum baseline accuracy was 99.8%, and the minimum was 21.7%. The mean normalized accuracy for all 54 runs was 96.7%, with a standard deviation of 1.095%. The reduction in primary task accuracy is statistically significant ($p=.0013$), indicating that the primary task required concentration; the addition of the secondary task affected the performance of the primary task.

For the secondary "warning" task, the mean accuracy across all 54 runs was 93.5%, with a standard deviation of 2.46%. The mean response time (for correct responses) across all 54 runs was 2.809 seconds, with a standard deviation of 0.631 seconds. The minimum response time was 1.331 seconds, and the maximum response time (within the limitations discussed in Chapter III) was 5.517 seconds.

Due to the massive size of the data base, only mean subject and group performances are presented in the thesis. Except as noted, however, the individual datapoints were used in statistical manipulations in order not to lose valuable information. The mean performance for each subject within each run is presented in Appendix D2 (SUBFIL). The mean group performance for all subjects within each run is presented in Appendix D3 (GPFIL). An explanation of the contents of the preceding two files is in Appendix D1 (File Conventions). Pertinent information about the secondary task was extracted from the appendices, and is presented in Table 1; data is listed in order of run sequence number. Most titles of Table 1 are self explanatory; "MN CORRECT" is the mean number of correct responses (maximum possible is 32) per subject for a particular run.

Run #	V-TYPE	BACKGRD	S/N-RAT	PRECURS	MN CORRECT	ACCURACY	RESP-TIME
1	Machine	115	0	Voice	25.700	0.803	2.745
2	Male	115	10	Tone	30.500	0.953	2.557
3	Male	105	10	Tone	29.800	0.931	2.537
4	Female	115	10	Repeat	30.200	0.944	2.503
5	Male	115	5	Voice	29.400	0.919	2.811
6	Machine	105	0	Tone	28.100	0.878	2.682
7	Female	105	10	Voice	30.700	0.959	2.788
8	Male	115	0	Repeat	30.400	0.950	2.700
9	Machine	115	5	Tone	27.500	0.859	2.762
10	Machine	105	0	Voice	29.600	0.925	2.877
11	Female	105	10	Repeat	31.200	0.975	2.686
12	Machine	115	0	Tone	29.100	0.909	2.816
13	Male	115	5	Tone	29.800	0.931	2.852
14	Female	105	5	Repeat	30.600	0.956	2.849
15	Female	105	0	Tone	30.600	0.956	2.666
16	Male	115	0	Voice	30.000	0.937	2.979
17	Female	115	5	Tone	29.400	0.919	2.743
18	Male	105	0	Repeat	31.200	0.975	2.958
19	Machine	105	0	Repeat	31.200	0.975	3.030
20	Female	115	0	Voice	26.700	0.834	3.017
21	Machine	105	10	Repeat	30.800	0.962	3.144
22	Female	105	0	Voice	30.000	0.937	2.975
23	Female	115	5	Voice	28.700	0.897	2.876
24	Male	105	5	Tone	30.700	0.959	2.760
25	Male	115	10	Repeat	31.300	0.978	3.020
26	Machine	105	10	Tone	29.900	0.934	2.722
27	Female	115	0	Repeat	29.400	0.919	2.694
28	Machine	115	10	Tone	30.300	0.947	2.721
29	Machine	115	5	Repeat	30.800	0.962	2.907
30	Male	105	10	Repeat	31.500	0.984	2.917
31	Female	115	0	Tone	29.700	0.928	2.712
32	Male	115	5	Repeat	31.300	0.978	2.937
33	Male	105	10	Voice	30.300	0.947	2.974
34	Female	105	10	Tone	30.300	0.947	2.667
35	Machine	115	5	Voice	29.400	0.919	2.961
36	Machine	115	10	Repeat	30.900	0.966	2.973
37	Male	105	0	Tone	29.200	0.913	2.693
38	Female	105	5	Voice	30.300	0.947	2.788
39	Male	115	0	Tone	28.700	0.897	2.661
40	Female	115	10	Voice	29.300	0.916	2.806
41	Female	105	5	Tone	29.600	0.925	2.583
42	Machine	105	5	Tone	30.000	0.937	2.663
43	Male	105	5	Voice	30.400	0.950	2.761
44	Machine	115	10	Voice	28.900	0.903	2.964
45	Female	115	5	Repeat	29.100	0.909	2.869
46	Machine	105	10	Voice	30.800	0.962	2.893
47	Female	115	10	Tone	31.000	0.969	2.602
48	Machine	115	0	Repeat	30.500	0.953	2.764
49	Machine	105	5	Repeat	30.700	0.959	2.877
50	Machine	105	5	Voice	30.400	0.950	2.953
51	Male	115	10	Voice	30.500	0.953	2.857
52	Male	105	5	Repeat	30.900	0.966	2.838
53	Male	105	0	Voice	29.000	0.906	2.886
54	Female	105	0	Repeat	29.900	0.934	2.696

Table 1. *Mean Results by Run Number*

Validation of Experimental Design

The data were analyzed initially for two purposes. First, statistical tests were performed to validate the experimental design. Second, results from some of the tests helped direct the design for the MANOVA by providing information on variables to include as treatments and covariates. Throughout the analysis, statisitical significance was considered critical at the level of alpha=0.05.

Regression of Accuracy Against Speed

The null hypothesis was that there was no relationship between accuracy and speed of response. If the null hypothesis could not be rejected, then analysis would be simplified by allowing separate analysis of the two variables.

Due to the fact that the response accuracy in the raw data files is a binary dependent variable ("correct" or "incorrect"), the raw data file could not be used to check for a linear relationship between the accuracy of response and the speed of correct responses without extensive transformation (Neter & Wasserman, 1974). Using the mean subject responses for each run, a regression was tabulated for accuracy against speed. To investigate the effect of voice type on the relationship, male and female voices were used as "dummy" variables, and the regression was run twice: once using accuracy by time, and again using time by accuracy. The results are in Table 2. The adjusted

R-square indicates the percentage of the variation of the dependent variable which is explained by the independent variable. The Slope/Coeff. column shows two things: the slope of the regression line for accuracy-time, and the coefficient for the dummy variables. The F/Part-F column shows the F-value for the whole model on the first line, and the partial-F for the model using stepwise inclusion on subsequent lines (Nie et al., 1975). A significant coefficent for the dummy variable indicates that the mean value for the dependent variable is significantly different for different levels of the dummy variable; the slope of the relationship is not affected. The column indicating the significance of F lists the smallest significance level at which the null hypothess can be rejected.

Dependent Variable	Independent Variable	Adjusted R-Square	Correl. Coeff.	Slope/ Coeff.	F/ Part-F	Signif. of F	Is "F" Signif?
ACCURACY	TIME OF RESP.	0.0199	-0.1221		4.651	0.003	YES
	TIME OF RESP. (Partial)			-0.0203	8.133	0.004	YES
	MALE VOICE (Dummy Var)			0.0169	4.681	0.031	YES
	FEMALE VOICE (Dummy Var)			0.0015	0.035	0.851	No
TIME OF RESP	ACCURACY	0.0199	-0.1221		4.480	0.004	YES
	ACCURACY (Partial)			-0.733	8.143	0.004	YES
	MALE VOICE (Dummy Var)			-0.033	0.475	0.491	No
	FEMALE VOICE (Dummy Var)			-0.105	5.004	0.026	YES

Table 2. *Relationship Between Accuracy and Time*

The negative slope of the accuracy/time relationship indicates that, as accuracy increased, the time decreased; i.e., speed also increased. This finding goes against the intuitive feeling that, as speed increases, accuracy should *decrease*, since doing things faster is normally associated with less care and accuracy. This finding is, to say the least, interesting. A possible explanation is that those characteristics of the warning (voice type, precursor format, etc.) which increased the subjects' accuracy also enabled them to respond more quickly by reducing ambiguity.

The statistically significant positive coefficient for the male-voice dummy variable in the first regression indicates that the mean accuracy for the male voice was higher than that for the female and machine voices. Likewise, the significant negative coefficient for the female voice in the second regression indicates that the response time for the female voice was lower (i.e. faster reaction) than for the male or machine voices.

The statistical significance of the interrelationship between accuracy and speed emphasized the justification for requiring a MANOVA with two criterion variables, as opposed to running two separate ANOVA's.

Within-runs t-tests

The null hypothesis was that there was no difference in the mean accuracy or speed of response between the first one-third stimuli within each run and the last one-third stimuli.

An author-generated program (Appendix C2) was used to perform the grouped t-tests of accuracy and response time within each run. The results are listed in Appendix E1. The was no evidence of either fatigue or learning curve for response time within any run. Seven of the fifty-four runs showed evidence of diminished accuracy during the last one-third responses when compared to the first one-third responses. No variable stands out as consistent among the seven cases. Of the seven runs, two were for the male voice, two for the female, and three for the machine voice. The cases were not grouped together in sequence number, nor do they appear predominantly at the beginning, middle, or end of the experiment. There is thus no evidence that any particular voice type promotes fatigue more than any other voice type. Additionally, subject performance within each run appears to be fairly stable.

ANOVA and Regression of Accuracy Across Runs

The null hypothesis was that the accuracy of response remained constant across the runs; that is, the subjects' accuracy did not show a significantly positive or negative trend due to acclimation with the experiment.

The ANOVA of accuracy across the run numbers was statistically significant ($F=6.699$, $p=0.000$). The Scheffe procedure divided the runs into two subsets. The groupings, however, were both large, and not necessarily grouped near the beginning, middle, or end of the run numbers. For subset I, only runs 11, 18, 19, 25, 30, 32, and 47 were not included. All those runs had the "repeated" precursor except run number 47, which had tone.

The only run not to be included in subset II was run number 1. Although the ANOVA showed a significant difference by the treatment of run number, nothing became evidently apparent as to the reason for the difference.

A regression of accuracy across the runs did not use the raw data file, again due to the binary nature of the "accuracy" variable in that file (Neter & Wasserman, 1974). Therefore, the regression used the mean subject accuracy for each run. Voice types were included as dummy variables to investigate the effect of voice type on the relationship. The results are in Table 3.

Dependent Variable	Independent Variable	Adjusted R-Square	Correl. Coeff.	Slope/ Coeff.	F/ Part-F	Signif. of F	Is "F" Signif?
ACCURACY	RUN NUMBER	0.0160	0.10074		3.916	0.009	YES
	RUN NUMBER (Partial)			0.001	5.951	0.015	YES
MALE VOICE (Dummy Var)				0.019	5.634	0.018	YES
FEMALE VOICE (Dummy Var)				0.004	0.294	0.588	No

Table 3. *Relationship Between Accuracy and Run Number*

The regression indicates that the linear relationship was statistically significant. The positive slope shows that accuracy increased (albeit very slightly) over the course of the experiment. The significant positive coefficient for the male voice indicates that the mean accuracy in response to the male voice was higher than for the female and machine voices. The small value of R-squared warns us that, although significant, the run number explained only a very small percentage of the variation.

ANOVA and Regression of Speed Across Runs

The null hypothesis was that the speed of response remained constant across the runs; that is, the subjects' time to respond did not show a significantly positive or negative trend due to acclimation with the experiment.

The ANOVA of response time across runs was statistically significant (F=15.853, p=0.000). The Scheffe precedure grouped the treatment effects into seven subsets. Each subset included 41, 24, 21, 48, 48, 48, 48, and 37 runs respectively. The subsets were not obviously grouped near the beginning, middle or end of the run numbers. No single treatment was obvious in explaining the difference between the seven subsets.

To investigate the possibility of a linear relationship, a regression of the response time with the run number was performed using the raw data file. Only response times for correct responses were included. The regression showed a statistically significant (F=21.831, p=0.00) positive slope. However, the slope was extremely small (0.00149) and the adjusted R-squared was also small (0.00129). To investigate further, another regression was performed using the subject mean responses, and including voice types as dummy variables. The results of this second regression are in Table 4.

Dependent Variable	Independent Variable	Adjusted R-Square	Correl. Coeff.	Slope/ Coeff.	F/ Part-F	Signif. of F	Is "F" Signif?
TIME OF RESP	RUN NUMBER	0.0060	0.04581		2.082	0.102	No
	RUN NUMBER (Partial)			0.001	1.007	0.316	No
	MALE VOICE (Dummy Var)			-0.044	0.855	0.355	No
	FEMALE VOICE (Dummy Var)			-0.106	5.054	0.025	YES

Table 4. *Relationship Between Response Time and Run Number*

The regression of speed across runs using mean subject response times was not statistically significant. Therefore, the null hypothesis cannot be rejected, indicating that there is little reason to suspect that the response time changed significantly as a function of experience. The fact that the partial-F for the female voice was significant is merely an indication that, although we cannot reject the null hypothesis that the slope of the regression is zero, the mean response time (accurate responses only) for the female voice, given that all other variables are already in the model, is significantly different.

Regression of Normalized Primary Task Accuracy Across Runs

The regression of the normalized primary task accuracy (as defined in section four of Chapter III) across runs was an indication of the extent to which the subjects were distracted by the secondary task. If the ratio was to increase as the run number increased, then that would indicate that the subject was becoming less distracted by the warnings as the experiment progressed. The null hypothesis was that normalized accuracy was constant across the runs; that is, the subjects did not become more or less bothered by the warnings as time went on. The results of the regression are in Table 5.

Dependent Variable	Independent Variable	Adjusted R-Square	Correl. Coeff.	Slope/ Coeff.	F/ Part-F	Signif. of F	Is "F" Signif?
NORM ACC	RUN NUMBER	0.0126	0.10106		3.293	0.020	YES
	RUN NUMBER (Partial)			0.001	5.822	0.016	YES
	MALE VOICE (Dummy Var)			0.009	0.558	0.455	No
	FEMALE VOICE (Dummy Var)			0.024	4.198	0.041	YES

Table 5. *Relationship Between Normalized Primary Task Accuracy and Run Number*

The results of the regression show a small positive relationship between the run number and the normalized primary task accuracy. This may be an indication that, as the subjects became more accustomed to the experiment, they were less distracted from their primary task. Again, however, both the slope and the adjusted R-squared are extremely small, indicating that, although significant, the relationship is slight.

The results of the analyses for accuracy, speed, and normalized primary task performance across run numbers showed slight but significant amounts of the variation explained by the run number (i.e., how far along the experiment had progressed). The fact that the amounts explained were slight suggests that the subjects were at or near the top of the learning curve, and were fairly proficient in the tasks assigned to them. With regard to response time, although the ANOVA indicated significant subgroups for the treatment effects, the regression failed to indicate any statistically significant linear relationship. The fact that the amounts explained were significant in the ANOVA was cause for including the run number and normalized primary task performance as covariates in the MANOVA design.

Analysis of Treatment Effects

MANOVA

A MANOVA was performed, using voice type, background noise, signal to noise ratio, and precursor type as the treatments, with blocking on the subject number. Subject number was not included in any of the two, three, or four way interaction effects. The primary reason for blocking on the subject number was to explain as much of the variation as possible due to the obviously different performance norms for each subject (see Appendix D2). The three way interaction of background noise by signal to noise ratio by precursor was not included in the analysis because the CYBER computer kept getting a large number which it was incapable of handling when that combination was part of the MANOVA design. The MANOVA was first examined using Hotellngs's T-squared to test the null hypothesis that, in this repeated-measures design, the variance-covariance matrix between treatments was homogeneous. If the homegeneity assumptions were met, the Hotellings' T^2 and the usual F test give identical results (Hull & Nie, 1981). The results of the MANOVA are in Appendix E2. A summary of the significant effects has been brought f-rward into the text, and is in Table 6, below. After ·amining the multivariate tests for significance, the univariate F-statistics were examined to see

> if the groups are significantly separated by any of the variables when considered one at a time. We might discover that a single variable is quite powerful in separating groups, and when this is the case we'll have found a simpler explanation for the group differences (McNichols, 1980, p. 7-69).

Some of the treatments may have a significant effect on the combined effects of accuracy and speed, but may not be significant on one or the other by itself. Alternatively, a treatment may not be significant when contemplating the combination of accuracy and speed, but may be significant in explaining the differences of one without the other. In the latter case, the word "YES" was bordered by parentheses in Appendix E2 and in Table 6.

TREATMENT	MULTIVARIATE SIGNIFICANCE	UNIVARIATE SIGNIFICANCE	
		ACCURACY	RESPONSE TIME
VOICE TYPE [VTYPE]	YES	YES	YES
BACKGROUND [BKGRD]	YES	YES	No
SIG/NOISE [SNRAT]	YES	YES	No
PRECURSOR [PREC]	YES	YES	YES
SUBJECT NO.	YES	YES	YES
VTYPE X BKGRD	YES	YES	YES
VTYPE X SNRAT	No	No	(YES)
VTYPE X PREC	YES	No	YES
BKGRD X SNRAT	No	No	(YES)
BKGRD X PREC	YES	YES	YES
SNRAT X PREC	YES	No	YES
VTYPE X BKGRD X SNRAT	No	No	No
VTYPE X BKGRD X PREC	YES	YES	No
VTYPE X SNRAT X PREC	YES	YES	YES
VTYPE X BKGRD X SNRAT X PREC	YES	YES	No

Table 6. *Significant MANOVA Effects*

Of the fifteen treatments and interactions listed, all but three discriminated in the multivariate sense. The single-treatment effects of voice type, precursor, and subject number discriminated in the multivariate and in both univariate analyses.

There were only three multiple-effect interactions to discriminate in all three analyses: the two-way interaction of voice type by background, the two-way interaction of background by precursor, and the three-way interaction of voice type by signal to noise ratio by precursor.

Interestingly, two of the interactions (voicetype by signal to noise ratio and background by signal to noise ratio) were effective in discriminating on response time for the univariate analysis; this discrimination was lost, however, when looking at the multivariate effect on accuracy and response time.

Investigation of Significant Treatment Effects

Because all single-treatment effects were significant in the multivariate sense for accuracy and speed, a univariate ANOVA was run for each of the variables individually. The detailed results of the ANOVAs appear in Appendix E3. A Summary of the results appears below in Table 7.

	UNIVARIATE SIGNIFICANCE	
TREATMENT	ACCURACY	RESPONSE TIME
VOICE TYPE [VTYPE]	YES	YES
BACKGROUND [BKGRD]	YES	No
SIG/NOISE [SNRAT]	YES	No
PRECURSOR [PREC]	YES	YES

Table 7. *Significant Univariate ANOVA Effects*

The results of the univariate ANOVAs using the complete database agree with the univariate single-treatments of the MANOVA using the mean subject performance data. The voice type and precursor were significant for both accuracy and response time, while background noise and signal to noise ratio were significant only for accuracy.

The Scheffe Method of Multiple Comparison was again used to identify the groupings of the treatments. Detailed results are in Appendix E3, and are summarized below. In the following description, the word "better" will apply to statistically significant *greater* accuracy or *shorter* response times. By variable, the results were as follows:

Voice Type
Accuracy for the male voice was better than for the female or machine. Response time for the female voice was better than for the male or machine; response time for the male voice was better than for the machine.

Background
Accuracy at 105 db was better than at 115 db. Response time was not statistically differentiated by differences in the background engine noise.

Signal to Noise Ratio
Accuracy for warnings presented at 10 db above the headphone conversation level was better than other signal to noise ratios; accuracy for warnings presented at 5 db was also better than at 0 db. Response time was not affected by the different signal to noise ratios.

Precursor
Accuracy for the repeated warning (double call-out), in which the warning acted as its own precursor, was better than the other two presentation styles. Response time for the tone precursor was better than for repeated or voice precursors.

When trying to make sense of the results of these analyses, two things must be kept in mind:

> 1. The results of the ANOVA should not be explained by themselves, but must be interpreted in light of the results of the MANOVA.
>
> 2. The response time was calculated only for those responses which were correct. Response times for innacurate responses were not included. Therefore, a "better" response time means that the response was faster, given the condition that the response was correct in the first place.

<u>Differences by Subject's Sex</u>

Because subject number was significant in the multivariate sense, an obvious question arose: was there any explainable aspect of the subjects which could account for this significance? To investigate that question, an ANOVA of accuracy and response by sex of the subject was performed in addition to an analysis of the above moderating variables. An analysis for grouping was performed only on the basis of the subject's sex for two reasons:

> (1) The authors anticipated a question as to whether men and women responded differently.
>
> (2) Because this was not intended to be a demographic study, the authors limited the analysis to one of the more obvious differences among the subjects. Since there were only ten subjects, the authors felt that any deeper analysis of performance by the subject's sex would be fraught with misinterpretation.

The detailed results of the analysis are in Appendix E4. A summary of the results reveals the following:

> The subject's sex was significant for both accuracy and response time.

The male subjects performed better for accuracy than the females; the females performed better for response time.

The male subjects showed no statistical difference in their accuracy for any of the three voice types. With respect to speed, the male subjects showed no statistical difference in response time between the male and female voice (subset 1 in the Scheffe method) or between male and machine voice (subset 2); however, they did respond better in subset 1 than in subset 2.

The female subjects had better accuracy in response to the male voice type than to the female or machine. They had a better response time to the female voice than to the male or machine voices.

When evaluating the subject's performance based on sex, it should be noted that both the primary tracking task and the secondary warning task were completely new tasks for all subjects, and that all subjects received equal amounts of training.

Length of Warnings

The mean length of the warnings given by the female voice was significantly shorter than that given by both the male voice and the machine voice; that is, it took the female speaker less time to call out the warning. The length of the three-word warning (right red one, etc.) as spoken by the female voice was approximately 0.12 seconds shorter than that of the male or machine voice. The difference in the speed of response to the different voice types was shown to be significantly different, with the response to the female voice approximately 0.07 seconds faster than to the male or machine voice. This raised the question of whether the faster response time was due to the shorter length of the warning itself

To investigate this possibility, the response times were adjusted by the mean length of the warning. The length of each warning was dependent on the voice type, the length of the precursor, and the length of the three-word warning phrase. Additionally, a short pause was interjected between the precursor and the warning itself to prevent forward masking. The duration of each warning is listed in Table 8.

	REPEATED WARNING	VOICE PRECURSOR	TONE PRECURSOR
MALE VOICE	2.267	1.641	1.421
FEMALE VOICE	2.024	1.590	1.298
MACHINE VOICE	2.238	1.626	1.407

Table 8. *Length of Warnings, in Seconds*

Another ANOVA was run, after the appropriate time was subtracted from the actual response time for each response. The results of the ANOVA using adjusted response times are in Appendix E5. A summary of the significant effects are in Table 9.

	UNIVARIATE SIGNIFICANCE	
TREATMENT	ACCURACY	RESPONSE TIME
VOICE TYPE [VTYPE]	YES	YES
BACKGROUND [BKGRD]	YES	No
SIG/NOISE [SNRAT]	YES	No
PRECURSOR [PREC]	YES	YES

Table 9. *Significant Univariate ANOVA Effects Using Adjusted Response Times*

As can be seen by comparing Table 9 with the results using unadjusted response times, those variables which were significant using normal response time were still significant discriminators when using the adjusted response time. As expected, the accuracy results did not change. The results for response time, however, did change. By variable, the changes were as follows:

Voice Type
After adjusting the response times to remove the length of the warning, the male voice had a better response time than either the female or machine. There was no significant difference between the response times for the female and machine voices.

Background
Background engine noise did not statistically distinguish between response times, just as with the unadjusted times.

Signal to Noise Ratio
Response time was still not affected by the different signal to noise ratios.

Precursor
Using the adjusted response times, the repeated warning (double call-out) was not only more accurate, but also had a shorter response time. Since the adjusted response time is a measure of the time from

the end of the entire warning, the significantly shorter adjusted response time for the double call-out is not surprising. The voice precursor, using the word "warning", was associated with a better response time than the tone precursor, although there was no distinction betwen these latter two with respect to accuracy.

Subject Sex

Women still had a significantly better response time for correct responses. Among both the male and female subjects, the grouping of the subsets by voice type changed after adjusting for the length of the warnings.

For both subject sexes, adjusted response time for the male voice type was significantly better than for female or machine. The adjusted response times for female and machine voice types were not significantly different from each other.

Adjusting the response times for the length of the warning indicates that the male voice may be better. Response time is normally measured from the beginning of the warning, however, not the end. Therefore, these results should be interpreted with caution, and only in light of the interaction of effects highlighted by the MANOVA.

Subject Questionnaire

To help ascertain, in retrospect, the impressions of the subjects themselves regarding the experiment, a short questionnaire was completed by each subject after the last day of the experiment. A copy of the questionnaire, with the instructions for its completion, is in Appendix F. The subject responses have been annotated on the questionnnaire. Analysis of the completed questionnaires reveals the following:

1. Six out of the ten subjects (all four males, two of the females) felt more *comfortable* responding to the MALE voice, while four of the subjects (all female) felt more *comfortable* responding to the FEMALE voice. None chose the MACHINE voice.

2. Six of the subjects (all four males, two of the females) felt they responded more *accurately* to the MALE voice, while four (all female) felt they responded more *accurately* to the FEMALE voice. None chose the MACHINE voice.

3. Four of the subjects (one male, three females) felt they responded more *quickly* to the MALE voice, while six subjects (three males, three females) felt they responded more *quickly* to the FEMALE voice. None chose the MACHINE voice.

4. Four of the subjects (two males, two females) *preferred* the MALE voice, while six (two males, four females) *preferred* the FEMALE voice. None chose the MACHINE voice.

Especially because the subjects involved were not rated crewmembers, drawing inferrences from these responses is dangerous. Two points, however, stand out:

1. None of the subjects preferred the machine voice nor felt they responded best to that voice type.

2. Considering the number of subjects, there was a fairly even split for choosing between the male and female voice for comfort, response and preference.

CHAPTER V

CONCLUSIONS

A basic philosophy throughout this experiment was that a response must be accurate to be useful. For that reason, the authors restricted the discussion of response time to correct responses.

The strong linear relationship between accuracy and speed of response indicates that any interpretation of the effects of a variable on accuracy or speed cannot be interpreted independently; an assessment of what is "best" can only be made in light of its significance in the multivariate sense. Each of the variables examined (voice type, backgound engine noise, signal to noise ratio over the headphones, and precursor) was significant in its effect on the combined criterion of accuracy and speed. Additionally, interactions among the independent variables themselves were significant in their effect, down to the four-way level of interaction.

The results of the experiment show that there is a statistically significant difference in response to warnings given by different voice types. The male voice was associated with a greater accuracy than that of the female or machine voice. For time of response, the findings are slightly more complicated. The unadjusted results point to the female voice as that which was associated with faster response times, given that the responses were accurate. After adjusting for the length of the warnings, however, the male voice was associated with the faster response. The machine voice was associated with the least accuracy and slowest speeds.

Within the range of background engine noises examined (105 and 115 db), the lower engine noise was associated with greater accuracy. There was no significant distinction for the time of response.

For the signal to noise ratio, in which the loudness of the voice warning was measured against the normal conversation level over the headset, the highest ratio (10 db) was associated with the most accurate response. The lowest ratio (0 db), in which the warning was given at the same volume as the conversation, was associated with the least accuracy. There was no significant difference in response time among the three levels (0, 5, & 10 db) examined.

The precursor variable examined three delivery formats: tone precursor, voice precursor, and repeated warning. The repeated warning, wherein the warning acted as its own attention-getting device, was associated with the highest level of accuracy. For response times, the tone precursor was associated with the fastest response, given that the responses were accurate. After adjusting for the length of the warning, however, the repeated warning was associated with the faster response times as well the greater accuracy.

Although this experiment was not intended to be a demographic study, the results prompted some limited investigation of differences in accuracy and speed associated with the sex of the subject. The subject sex was significant in both univariate analyses. The men were associated with the greater accuracy, while women were associated with the faster time, given an accurate response. For the men, voice type did not discriminate in the accuracy of response. The women responded more accurately to the male voice.

The significance of voice type on the speed of response is slightly more complicated when grouping the subjects by sex. For the men, the unadjusted times indicated no significant difference in response time between the female and male voice types; the adjusted times, however, showed a significant difference in response time between the male and female voice types (male being better). Among women, response times for the unadjusted times clearly pointed to the female voice for the fastest response times. For adjusted times, conversely, the indications were just as clear, but in favor of the male voice for the fastest response times.

CHAPTER VI

DISCUSSION AND RECOMMENDATIONS

The results of this experiment contradict the common belief that the female voice is "better" in a cockpit voice warning system. The higher accuracy was associated with the male voice. While the shorter response time was associated with the female voice, this latter association is tempered by two facts:

1. Response times were calculated for correct responses only. Thus, the shorter time is dependent on the prior condition of accuracy, which was associated with the male voice.

2. There was a significant difference in the length of the warnings given by the male and female voices. When compensation was made for the length of the warnings, the male voice was more significantly associated with shorter response times.

Because response time is normally measured from the onset of the emergency, i.e. the beginning of the warning, adjusting the response time for the length of the warning message must be treated with caution.

Simpson and Williams (1980) found that response times to "semantic context" warnings were faster than those to warnings with a tone precursor, despite the fact that the tone took less time than the semantic context addition. They expected the word "warning" would act in the same manner as the semantic context. By their expectations, the voice precursor should have been associated with the shortest response time. Contrarily, the response time for the tone precursor was significantly shorter than for the voice precursor when using unadjusted response times. The word "warning" apparently did not act in exactly the same manner as changing the semantic context, as Simpson anc Williams expected.

Adjusting the response time for the length of the warnings also showed some interesting aspects of the warning format. The repeated warning format was associated with the fastest response time after adjusting the response times for the warning length. This result is hardly surprising for two reasons: (1) a larger number was subtracted from the total response time due to the longer message format, and (2) the repeated warning precursor provides more information than either a tone or the word "warning".

What is interesting, however, was the effect on the distinction between the other two precursor formats, tone and the voice "warning". Without adjustment, the tone was associated with the faster response time for correct responses. After adjustment, however, the voice precursor was associated with a faster response than the tone, and the tone precursor was associated with the slowest response time.

Although the better accuracy was associated with the higher signal to noise ratio, this result should not be extended ad infinitum. Above a certain level, sound can be not only irritating but physically harmful. The signal to noise ratios used in this experiment were sufficient to deliver the warning without apparent irritation or harm. Nonetheless, further testing may be needed to ascertain the optimal level.

All variables examined were significant in the multivariate sense, but not necessarily in the univariate sense for both accracy and time. Some of the interactions (down to the four-way level) were also significant. Because not only the variables, but also the interaction of the variables, were significant in many instances, it is recommended that further study be conducted on the interaction of the variables.

Future experiments should investigate what aspects of the voice are most significantly associated with accuracy and speed of response. These might include, but are not limited to: frequency, intensity, pitch, timbre, intonation, and delivery style.

Because the results of this experiment contradict previous experiments and studies, the authors recommend that additional empirical evidence be gathered. Future experiments should include crew members of both sexes and should be conducted in aircraft simulators and/or actual aircraft. Voice recordings should be made by persons familiar with air traffic control vocabulary and procedures. Professional speakers with air traffic control experience would be preferable.

Given that the results of this experiment hold with replication, the authors recommend the use of a male voice in a cockpit voice warning system for military aircraft.

APPENDICES

APPENDIX A

VOCRES FACILITIES

LEVEL II

(12) B.S.

(14) AFAMRL-TR-80-25

Aerospace Medical Research Laboratory

(6) VOICE COMMUNICATION RESEARCH AND EVALUATION SYSTEM.

(10) RICHARD L. MCKINLEY

(9) Technical rept.,

(11) MAY 1980 (12) 17

(16) 7231 (17) 09

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TECHNICAL REVIEW AND APPROVAL

AFAMRL-TR-80-25

This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

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AIR FORCE/56780/27 June 1980 — 150

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFAMRL-TR-80-25	2. GOVT ACCESSION NO. AD-A088 100	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) VOICE COMMUNICATION RESEARCH AND EVALUATION SYSTEM		5. TYPE OF REPORT & PERIOD COVERED Technical Report
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Richard L. McKinley		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Air Force Aerospace Medical Research Laboratory Aerospace Medical Division, Air Force Systems Command, Wright-Patterson Air Force Base, OH 45433		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 62202F/7231/09/11
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE May 1980
		13. NUMBER OF PAGES 17
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Communications
Speech
Electronic Warfare
Noise
Voice Communication
Speech Intelligibility
Psychoacoustics

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Aircraft voice communications may be degraded by a variety of sources such as electrical and/or acoustical noise, radio interference, jamming and various other forms of distraction. The Voice Communication Research and Evaluation System, located in the Biodynamics and Bioengineering Division of the Aerospace Medical Research Laboratory, has been developed for the comprehensive analysis and enhancement of operational voice communication. The basic system is comprised of a multi-station voice communication network consisting of the USAF

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DD FORM 1473, 1 JAN 73 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) standard aircraft intercommunication system, a standard A-19 diluter-demand oxygen regulation system and an on line computer data collection and data analysis system that displays results in real time. The system is housed in a large reverberation chamber containing a programmable sound source capable of reproducing the spectrum and level of any AF operational noise environment. Standardized voice communication effectiveness test materials are used to assess the performance of any aspect of the total voice communication link, however, emphasis is usually placed upon the performance of the aircrew members. This paper will describe the salient features of this unique system and provide examples of its application to voice communication problems.

Accession For

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INTRODUCTION

Air and ground crew voice communications may be degraded by a variety of system and environmental factors that include electrical or acoustical noise or both, radio interference, jamming, communication signal processing and various other factors that prohibit effective communication. Vigorous research activities must be maintained to identify and quantify elements that cause such deterioration and to develop principles, techniques and guidelines that will minimize adverse effects and optimize voice communications. Analytical studies of communication system performance, environmental influences and the man-in-the-loop element must be carried out under carefully controlled conditions that simulate to the greatest extent possible, the practical, operational situations of concern. Such efforts are possible in controlled laboratory environments where special instrumentation can be used to create the essential elements of human factors and communication system networks being investigated.

A Voice Communication Research and Evaluation System (VOCRES), located in the Biodynamics and Bioengineering Division of the Air Force Aerospace Medical Research Laboratory has been developed to provide the capability for comprehensive research, test and evaluation activities in the voice communications effectiveness arena. VOCRES, the subject of this report, has been designed to replicate system and environmental variables believed to have significant influence on operational communication. Using VOCRES, various elements of voice communications can be analyzed either individually or in component clusters. Using this method of analysis, problem areas can be identified, attacked and the overall operation enhanced. The effectiveness of various interfering signals may also be evaluated by their insertion into the communication system. The operational procedures and materials used in the laboratory are well standardized and provide data with a high degree of reliability.

This report describes the VOCRES system instrumentation in some detail as well as the psychoacoustical procedures used in the overall operation of the voice communication research program. The key element of the overall program is VOCRES. Other component systems are essential to the realistic replication of communication situations for expanding the technology base as well as performing discrete measurements required for the treatment of specific problems.

APPROACH

The general approach employed in this program involves the participation of volunteers who communicate as talkers and listeners under controlled conditions that replicate the specific communication environments being evaluated. Subjects are stationed at custom-designed consoles and communicate with standardized or special purpose (speech) vocabulary materials while various system and environmental characteristics or equipment are varied and the resulting communication effectiveness is quantified. Elements commonly varied are microphones, earphones, ambient noise level at the crew station, helmets and oxygen masks, aircraft radios, jamming signal type and modulation, jammer to signal power ratios, and receiver input power. Data derived from these efforts may be used to establish baseline communication system performance profiles, for comparative testing of specific communication system components, such as radios, intercoms, microphones, earphones, and voice processors. The data are also used to quantify the performance of a specific component in a specific environment. Subjective comments from active aircrew personnel who have experienced the VOCRES reveal that the validity of the system and of the approach is quite good.

INSTRUMENTATION

VOCRES: General System

The VOCRES system is an aggregate of four different subsystems integrated into a voice communication network that includes ten individual communication stations and one control station. The individual communication consoles are located in a large reverberation chamber and the master console is located in a control room adjacent to the chamber. The general physical assemblage of the individual subsystems and the integrated system is displayed in Figure 1.

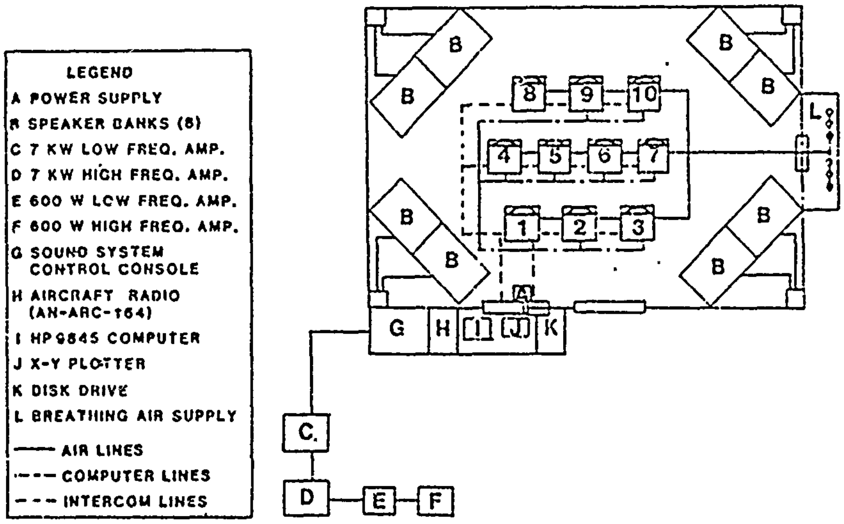

Figure 1. SUBSYSTEMS INTEGRATION

The subsystems include (1) an AIC-25 aircraft intercommunication system (11 stations), for use with Air Force standard communications headgear, (2) an air respiration system with A-19 diluter-demand regulators for use with standard oxygen masks, (3) a high intensity sound source for duplicating operational acoustical environments occupied by crew members and (4) a central processing unit that controls all stations and conducts the individual testing sessions and conditions, i.e., presents materials, monitors participant activity, records, stores and analyzes responses, and provides analyzed data in tabular or graphic form or both. The overall system is adaptable to the incorporation of various aircraft radios, communication jammers, and the like, that are not integral components of VOCRES.

Each of the ten communication consoles or stations is equipped with an AIC-25 intercommunication terminal, an A-19 respiration terminal, a display/subject response unit, a keyboard for communication performance task response from the participants and a large volume unit (VU) meter that indicates voice level of communications generated at that station (see Figure 2). The system can be operated with any number of one to ten volunteers. The psychophysical paradigm used most often is a "round robin" procedure where each subject, in turn, performs as a talker while the remaining subjects respond as listeners.

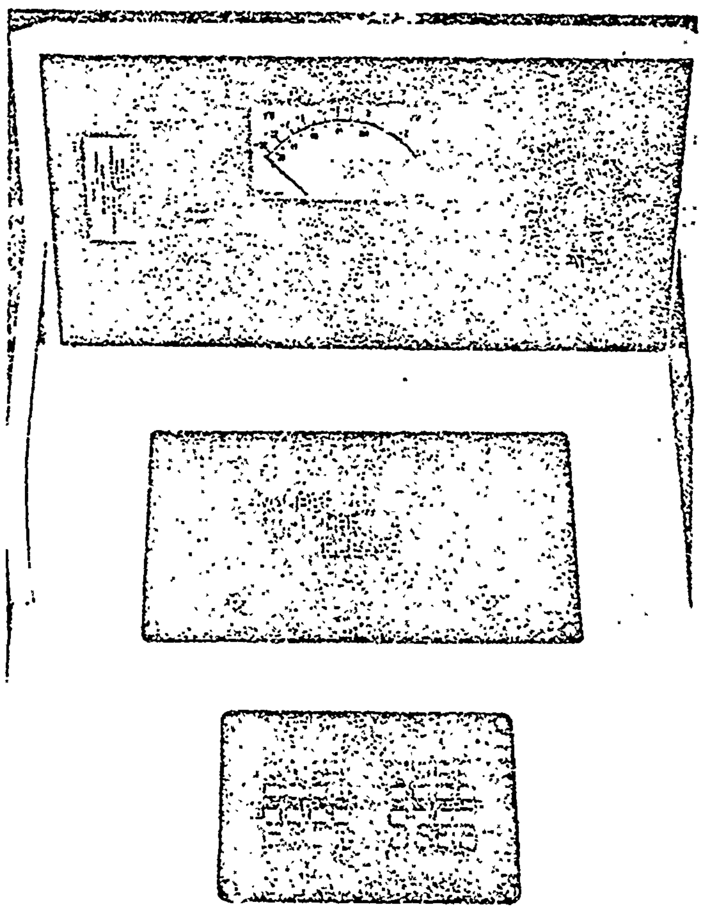

Figure 2. INDIVIDUAL VOCRES STATION (DESK)

COMMUNICATION MATERIALS

Communication materials consist of the standardized Modified Rhyme Test* for most activities with VOCRES. Other test materials such as the Diagnostic Rhyme Test are used from time to time for special purpose applications.

COMMUNICATION LINK CAPABILITIES

The communications assemblage diagram (Fig. 3) demonstrates the high flexibility of VOCRES that allows a variety of different communication links to be examined either

* Standardized lists of 50 monosyllabic words; each list developed to be essentially equivalent in intelligibility to the other lists.

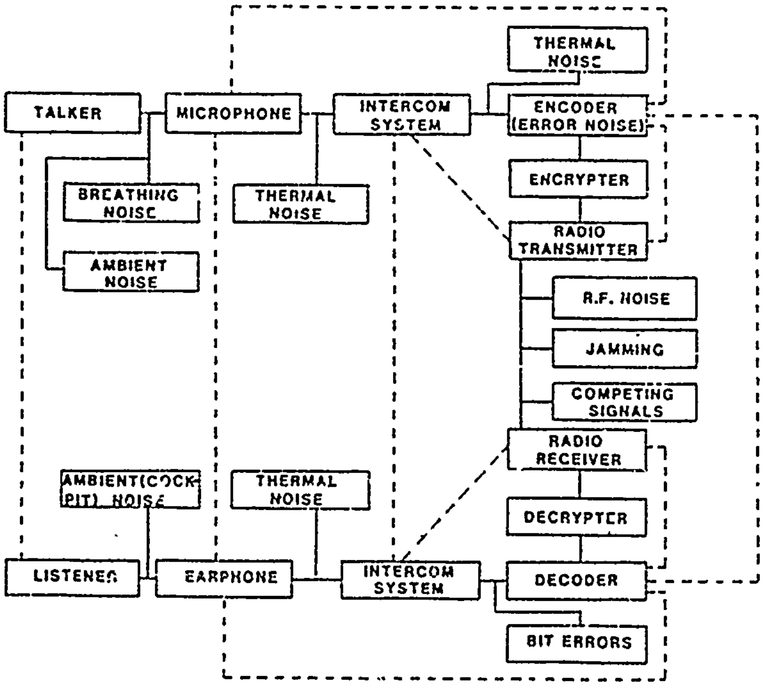

Figure 3. BLOCK DIAGRAM VOCRES COMMUNICATION LINK

individually or in combination with one another. The range of communication links can be varied from a simple face-to-face communications situation (i.e., direct talker to listener) to a complex configuration using encoders, encrypters, and the like by varying appropriate subunit controls. Any of the alternate pathways shown in Figure 3 can be used to complete the talker to listener link. The direct talker to listener path theoretically provides a data baseline free from environmental and component effects. The influences of the various elements of the communication system operation relative to the baseline can be quantified, analyzed and evaluated by measuring performance while varying single components and clusters of components of the VOCRES.

CENTRAL PROCESSOR-DISPLAY-RESPONSE SYSTEM

The control console of the system includes a typewriter type keyboard and a cathode ray tube (CRT) display. Through this console the test administrator enters the required experimental information. The central processing unit then displays the required instrument on the CRT (Fig. 4). After all experimental instrument settings are completed and stabilized, the administrator tells the central processing unit to administer the selected test and collect data from each of ten individual communications desks. The system is capable of making any one of the 10 stations the talker position and also can facilitate multiple talkers. For example, during a test one subject will be designated a talker for a list of 50 words and the other nine subjects will be designated as listeners. On the CRT the system displays each of the listeners' responses to each item spoken by the talker. The CRT display also indicates whether or not the response is correct (Fig. 5). The central processor-display-response system is diagrammed in Figure 6. The central processor is the Hewlett-Packard 9845T System. This system has dual 16-bit processors, wherein one handles internal functions, while the second handles I/O functions. Also included in the basic system are a CRT with graphics, a thermal line printer (8-1/2" wide) with graphics capability and two cartridge tape drives, each with 217K byte* capacity. A 20 Mega byte disk drive with two platters, one fixed and one removable, adds additional data storage capability. Several interfaces are also included in the system. An RS-232 interface is used for sending and receiving data from the individual communication stations, while an IEEE 488-1975 General Purpose Interface Bus is used for control and data collection from various electronic instruments. These include a digital spectrum analyzer, a frequency synthesizer, a digital voltmeter, an RF power meter, and a 4-color flat bed X-Y plotter. A second RS-232 interface receives data from a digital oscilloscope or an audio tape deck.

Each individual communication desk has its own RS-232 compatible interface shown in Figure 4 & 5 which decodes commands by the central processor for the display system and also returns the subjects' responses to the central processor for storage and analysis. Each desk station interface has two addresses to which it will respond. One address is common to all desks, therefore by using one address and message, all desk displays can be activated or loaded simultaneously. The second address is specific to only one desk and by using this address, ten different messages can be loaded into each of ten different displays. The interface for each desk operates at 9600 bits per second allowing seemingly simultaneous operation at each of the ten stations.

Figure 7 shows one of the 64 character alphanumeric gas discharge, type displays. Each character is 5.73 mm (.023 in) x 8.27 mm (0.33 in) and is generated by a 5x7 dot matrix with a separate underline capability. The display is very bright having a level of 30 ft-L. The contrast of the neon-orange characters is enhanced by the use of a circularly polarized filter.

The subjects can respond by using one of two different response systems. The first system consists of six pushbuttons, three on either side of the displays each with a red LED mounted in the bezel. Pressing one button causes the adjacent LED to light indicating a response has been made. Pushing a second button will allow the volunteer to change his decision, illuminating the second light instead of the first. The second response system consists of two 4x4 calculator type keypads. Only one of the 32 buttons can be chosen at one time. Operation is similar to the six LED pushbuttons except that pressing one of the keys causes from one to five of the six LEDs to light forming a specific pattern for that key. These LEDs provide feedback to the subject indicating the chosen response.

DATA TREATMENT

Computer software was developed to standardize test procedures and to facilitate the administration of the Modified Rhyme Test or any other standardized intelligibility test over a large number of individual trials. The software also includes the experimental design. Each test parameter is displayed on the CRT before the trial and appropriate equipment settings are made by both the test administrator and central processing unit. The individual units of the Modified Rhyme Test or any other test materials are stored on the system's 20 Mega Byte hard disk. Following each trial, data for each subject, all test parameters and the time of the trial are stored on the system's disk. Fail-safe backup is accomplished by printing the same data on the system's thermal line printer. The data

* Note: 1 byte = 8 bits

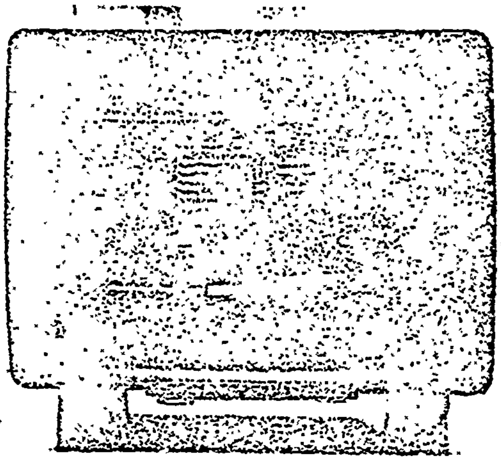

Figure 4. CENTRAL PROCESSING UNIT, CRT, OPERATOR PROMPTING

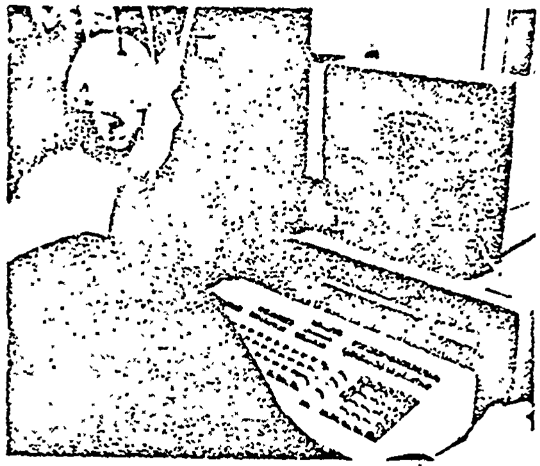

Figure 5. CENTRAL PROCESSING UNIT, CRT, SUBJECT RESPONSES

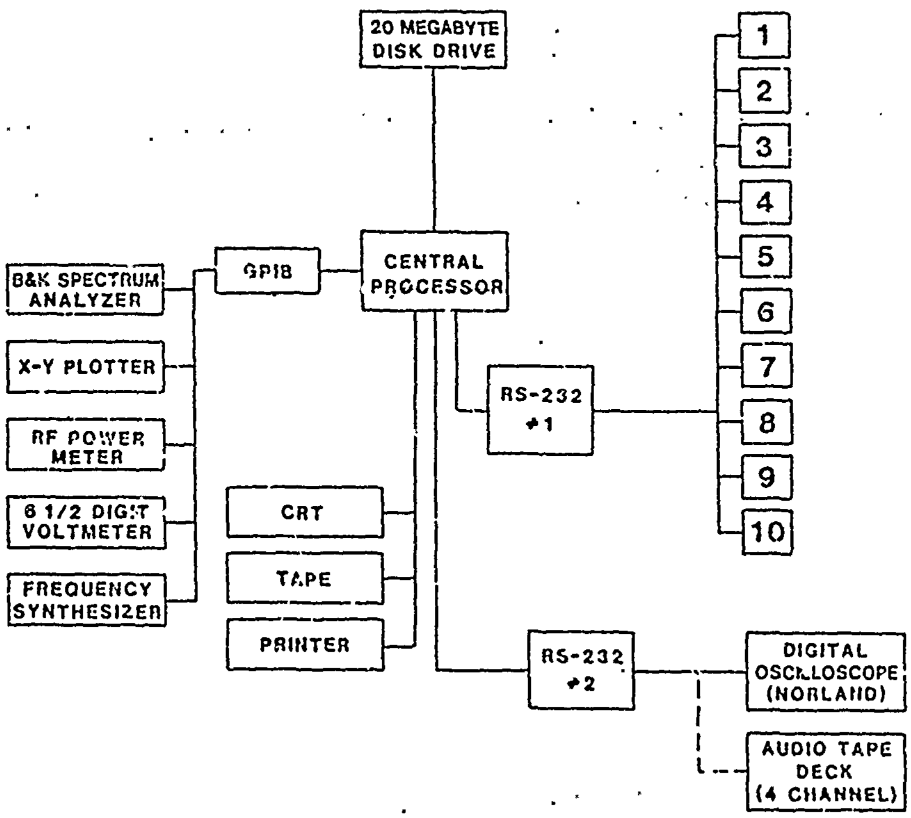

Figure 6. BLOCK DIAGRAM VOCRES CENTRAL PROCESSING UNIT

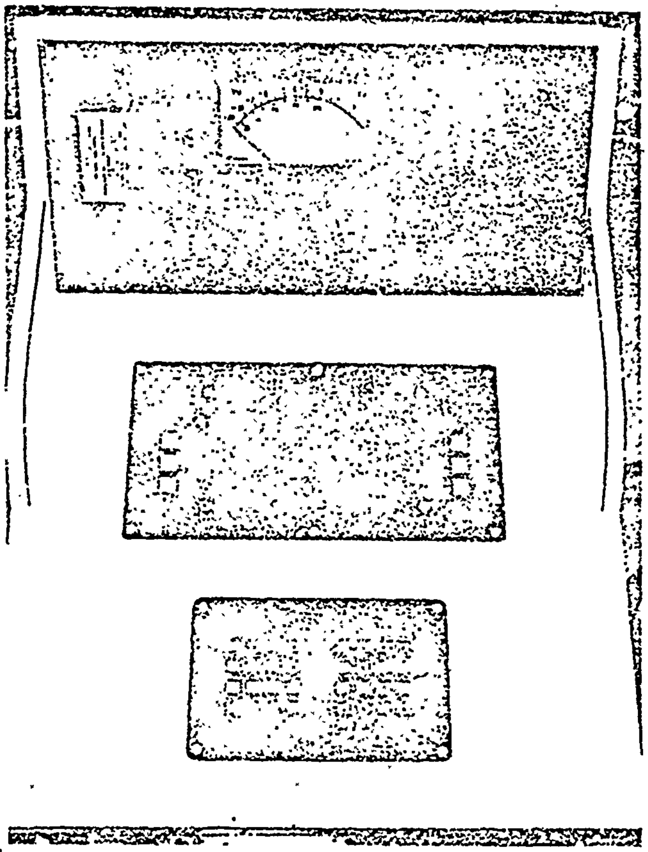

Figure 7. INDIVIDUAL DESK DISPLAY UNIT

may be analysed at any time, using a variety of standard statistical measures and plotting techniques. This method of data storage and analysis can give preliminary results in real time.

HIGH INTENSITY SOUND SYSTEM

The high intensity sound system is shown in Figures 8 and 9. The system is capable of operation in one of two power modes, a high power mode where 14,000 watts are available and a low power mode where 1,200 watts are available. The power amplifiers drive eight banks of loudspeakers containing a total of 96 Altec 15" low-frequency speakers, eight Altec horn loaded compression drivers, and 384 Stromberg Carlson high frequency speakers. The noise generator and the spectrum shaper allow almost any desired noise environment (spectrum) within the human audio-frequency range to be generated inside the test chamber. This permits the accurate reproduction of ambient and environmental noise conditions of specific operational situations within the laboratory, which is a vital aspect of the validity of the communication testing.

The room in which the loudspeaker banks are located is a specially designed and constructed acoustic reverberation chamber. The room is designed for maximum

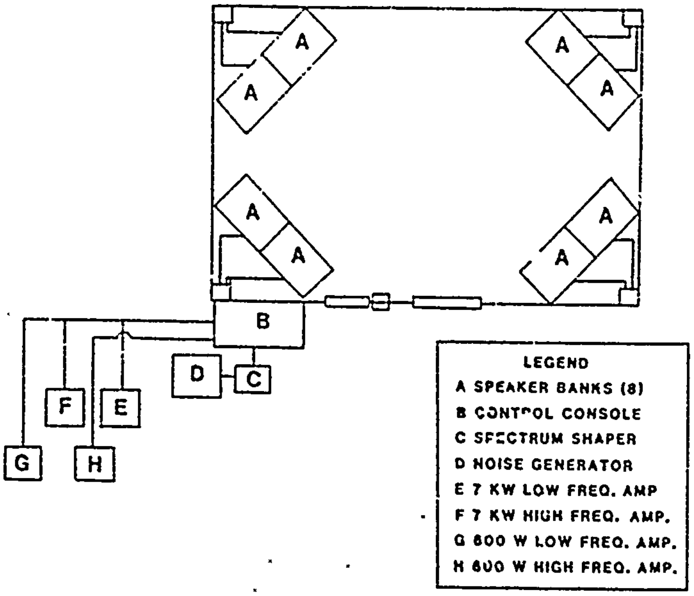

Figure 8. HIGH INTENSITY SOUND SYSTEM

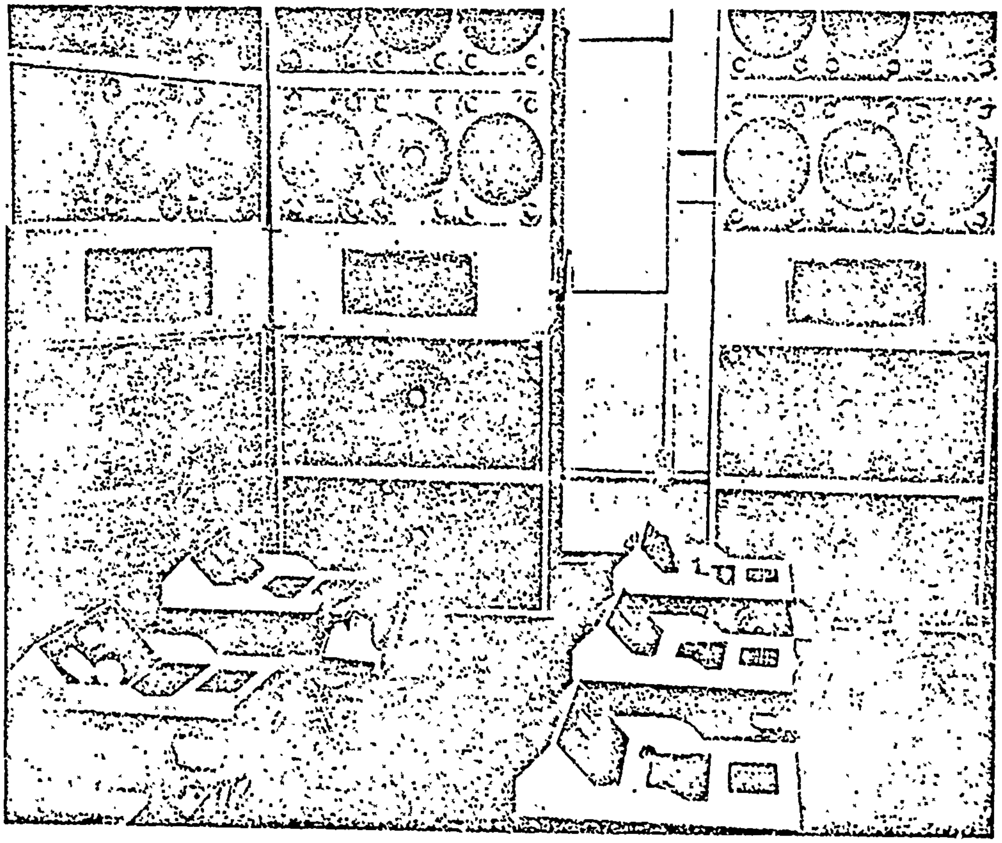

Figure 9. HIGH INTENSITY SOUND SYSTEM

reverberation time and approximately 8000 ft^3 in volume. The irregular wall surfaces are designed to disrupt the formation of standing waves and maximize the uniformity of the level of a noise distributed throughout the room.

AIC-25 INTERCOMMUNICATION SYSTEM

The aircraft intercommunication system shown in Figure 10 is a standard AIC-25 intercommunication system. The test administrator and each desk has an individual AIC-25 aircraft intercommunication unit . A switching circuit located on the control console allows the talker's intercom to be disconnected from the rest of the system and taken directly to the audio input of any transmitter. The audio output of the receiver is then routed to the other nine listeners. The terminal equipment available for the intercom system includes standard H-157A headsets, H-133 headsets, MBU-5/P oxygen masks, and HGU-26/P flight helmets. A sample of each of these is pictured in Figure 11.

AIR RESPIRATION SYSTEM

The air breathing system depicted in Figure 12 uses the standard Air Force A-19 diluter demand regulator as the primary item in the system. Each station has its own A-19 regulator which is supplied through feeder lines by a semiautomatic regulator manifold. The manifold connects six standard size breathing air bottles to the system through two regulators. Each regulator controls three bottles. When the supply of the first three bottles is exhausted the system automatically switches to the second set of three bottles. The normal operating pressure in the system is 150 psig.

Each of the above systems is integrated into each of ten individual subject stations. The final product is shown in Figures 13 and 14. The desk was designed for minimum size to minimize acoustical reflections from the surface and yet be functional. Each station is independent.

In the past, interim versions of the VOCRES system were used to evaluate communication properties of lightweight helmets, chemical defense ensembles, new oxygen masks, and innovative radio systems. Current studies involve the investigation of effects of jamming on communication in a quantitative manner relative to the J/S, S/N, radio type and jammer type, evaluation of new chemical defense ensembles, and development of new communication microphones. Future studies will include modeling of human response to jamming and enhancement of terminal communication equipment.

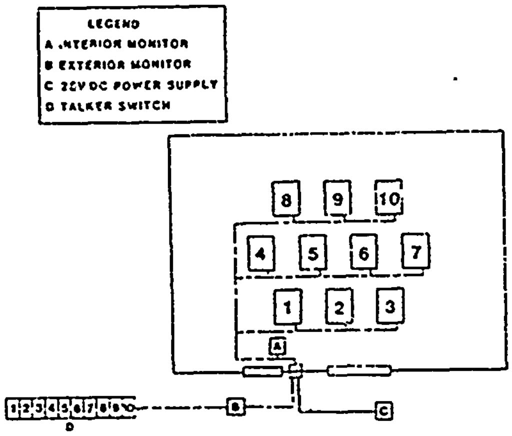

Figure 10. AIC-25 INTERCOMMUNICATION SYSTEM

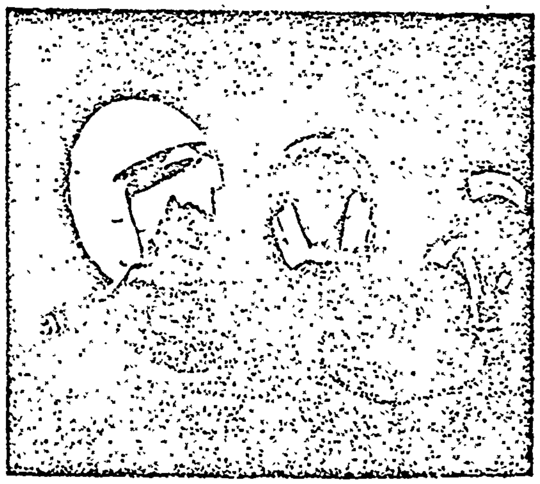

Figure 11. AIC-25 COMPATIBLE TERMINAL HEADGEAR

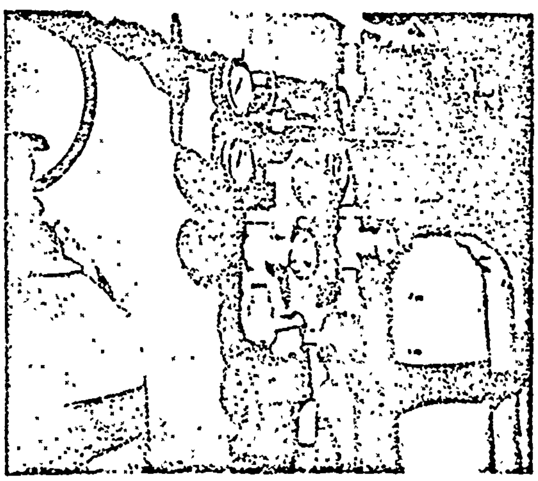

Figure 12. AIR RESPIRATION SYSTEM

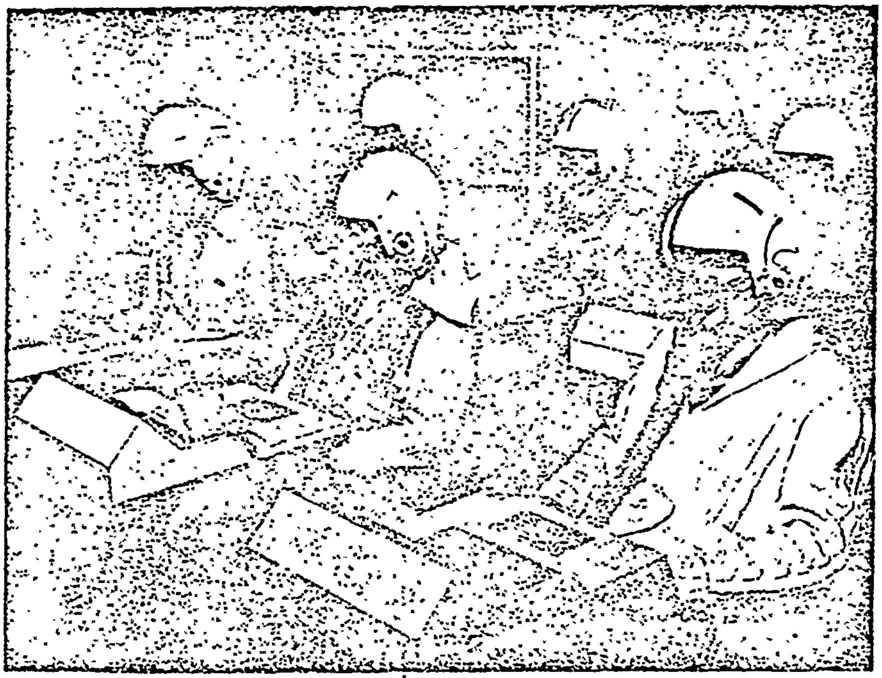

Figure 13. INDIVIDUAL VOCRES STATION (DESK)

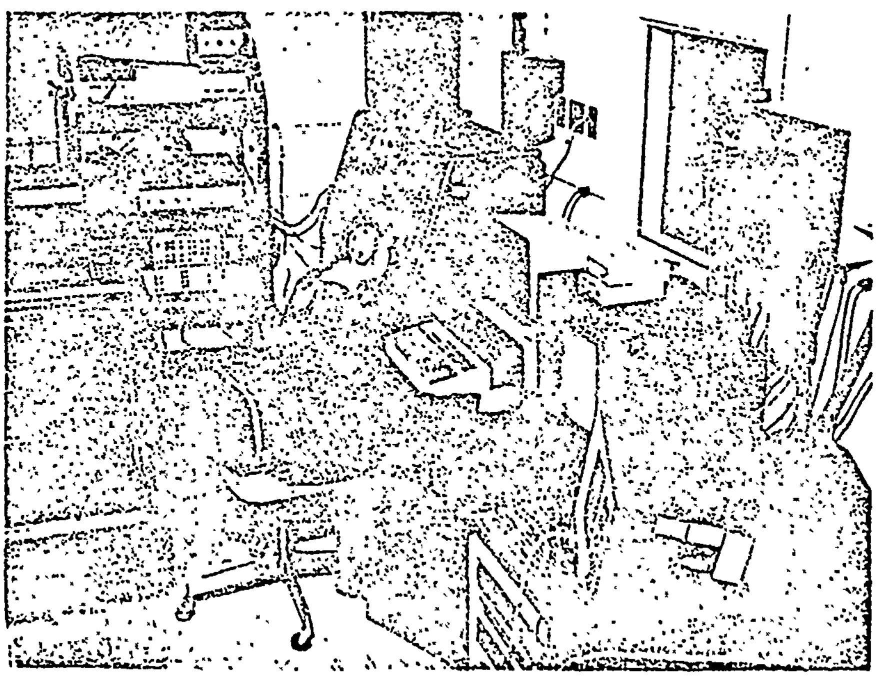

Figure 14. VOCRES SYSTEM

SUMMARY

This paper has described the VOCRES system, its capabilities and uses. In summary, VOCRES is a semiautomatic laboratory voice communication test system that uses human subjects in a realistic communication environment to conduct research, test and evaluation of Air Force communications systems and their effectiveness.

REFERENCES

House, A. S., Williams, C., Hecker, M. H. L., and Kryter, K. D. Psychoacoustic Speech Tests: A Modified Rhyme Test, ESD-TDR-63-403, Electronic Systems Division, L. G. Hanscom Air Force Base, MA, 1962

Voiers, W. D. Performance Evaluation of Speech Processing Devices. III. Diagnostic Evaluation of Speech Intelligibility. AFCRL-67-0101, Air Force Cambridge Research Laboratories, L. Y. Hanscom AFB, MA 1967

*U.S.Government Printing Office: 1980 — 657-084/780

APPENDIX B

TESTING PROCEDURES

APPENDIX B1

TEST PLAN

TEST PLAN

AFIT LS THESIS #89-83
ACCURACY AND SPEED OF RESPONSE
TO DIFFERENT VOICE TYPES
IN A COCKPIT WARNING SYSTEM

24 MAY 1983

PREPARED BY

____

JAY FREEDMAN & WILLIAM A. RUMBAUGH (AFIT/LS)

BRANCH APPROVAL (BBA) ______________________________

DIVISION APPROVAL (BB) ______________________________

TEST PLAN

AFIT LS THESIS #89-83:
ACCURACY AND SPEED OF RESPONSE TO DIFFERENT VOICE TYPES IN A COCKPIT WARNING SYSTEM

1. Experimental Test Planning Documentation

a. Test Objective and Purpose

The purpose of this study is to investigate the effects of different voice types (male, female, and machine) on the speed and accuracy of response to a voice warning system. The results of this study will be used in the design, development, and selection of auditory advisory annunciator systems for military aircraft.

b. Experimental Design

The variables to be investigated are 3 voice types (male, female, machine). The moderating variables are warning format, background noise, and signal-to-noise ratio. Warning format will take three forms: tone precursor, voice precursor (the word "Warning"), and repeated warning, in which the warning acts as its own precursor. Background noise will be 105 db and 115 db, which represent two high-noise situations in an F-16A cockpit. Signal-to-noise ratios will be 0, 5, and 10 db above headphone conversation noise, as delivered to the headphones over the intercomm system. All subjects will be tested under every experimental condition (54 combinations).

c. Experimental Procedures

Procedures are detailed in AFIT LS Thesis #89-83 Speed and Accuracy of Response to Different Voice Types in a Cockpit Warning System, Chapter III (Methodology).

There will be ten subjects, recruited by the AMRL. The only restrictions on the subjects are that they possess good hearing as measured by a standard audiometric screening test and that they can participate in all 54 tests. During the test, subjects will be required to perform two tasks: a primary "tracking" task, and a secondary "emergency response" task.

The primary task will consist of pushing the button closest to a marker on the LED display. The location of the marker continually changes in a random manner.

The secondary task will be to correctly respond to emergency warnings, which will be interjected periodically. The warnings will consist of instructions specifying which one of 32 buttons, located on a pad below the LED display, must be pushed. Each of the 32 buttons will be chosen at least once during each of the 54 tests.

During the course of each test session, data will be collected by a Hewlett Packard 9845T desktop computer system.

The data will subsequently be transferred to the AFIT/ASD CDC computer for analysis. Noise exposure conditions at the ear are within the limits specified by AFR 161-35, *Hazardous Noise Exposure*, and are nonhazardous. Procedures used are in accordance with AFR 169-3, *Use of Human Subjects in RDT&E*.

d. Test System Requirements

The standard Voice Communication Research and Evaluation System (VOCRES) facilities will be augmented with a digitized voice capability, generated by the Texas Instruments (TI) 5220 speech synthesis chip. Reference *Voice Communication Research and Evaluation System* (AFAMRL-TR-80-25), May 1980.

e. Data Processing Techniques

Data will be processed on the AFIT/ASD CDC computer, using the Statistical Package for the Social Sciences (SPSS). The SPSS program will calculate mean response times and accuracy for each condition, and indicate any appropriate correlations in the data set.

f. Documentation Requirements

This experiment is being documented under AFIT LS Thesis #89-83. This experiment is being performed in support of the Master's Degree program in Systems Management.

g. Mr. Timothy Anderson and Mr. Richard McKinley will be responsible for calibrating the test equipment, generating noise and test signals. Major Freedman and Captain Rumbaugh will be responsible for analysis and interpretation of the data.

h. Responsibilities of Technical Service Organization

BBE will be responsible for maintaining the high intensity sound systems.

i. Responibilities of WPAFB Support Organizations

None

j. Human Use Protocol

#78-13 "Nonhazardous Human Exposure to Acoustic Energy"

k. Instrumentation Calibration Procedures

Instrumentation shall be calibrated in accordance with BBE SOP #15.

l. Instrumentation Calibration Records

Calibration will be recorded at the beginning and end of each test. Records of calibration will be kept with the test data.

m. Facility Operational Procedures

Procedures shall be conducted in accordance with BBE SOP #14.

n. Facility Operational Checklists

VOCRES facility operational checklists will be provided by MR. Timothy Anderson and Mr. Richard Mckinley.

o. Description of Data Collection Systems

Speed and accuracy of response data will be collected by means of Hewlett Packard 9845T desktop computer. A hard copy, tape copy, and disk copy will be retained.

p. Test Schedule

Testing will commence on or about June 1, 1983.

q. Safety and Emergency Procedures

AMRL/BB Safety Officer has and will continue to conduct monthly safety inspections of experimental area.

2. N/A

3. Major Freedman and Captain Rumbaugh will be co-investigators. Experiments will be conducted under the guidance of Mr. Anderson and Mr. McKinley.

4. Mr. Anderson and Mr. McKinley will be the on-site operating officials.

APPENDIX B2

EXPERIMENTAL DESIGN SEQUENCE

EXPERIMENTAL DESIGN SEQUENCE

The combination of parameters and the original order were determined using random methods of selection. The random order thus arrived at is reflected in the "run parameter" code number. The combinations were then adjusted only when necessary to remain within USAF standards of noise exposure, as established by AFR 161-35, *Hazardous Noise Exposure*, and AFR 169-3, *Use of Human Subjects in RDT&E*. The final sequence is indicated by the "run sequence number".

RUN SEQUENCE NUMBER	RUN PARAMETER	VOICE TYPE	BACKGROUND NOISE (db)	S/N RATIO (db)	PRECURSOR TYPE
1	5	Machine	115	0	Voice
2	6	Male	115	10	Tone
3	13	Male	105	10	Tone
4	10	Female	115	10	Repeated
5	9	Male	115	5	Voice
6	11	Machine	105	0	Tone
7	14	Female	105	10	Voice
8	1	Male	115	0	Repeated
9	2	Machine	115	5	Tone
10	3	Machine	105	0	Voice
11	15	Female	105	10	Repeated
12	4	Machine	115	0	Tone
13	7	Male	115	5	Tone
14	16	Female	105	5	Repeated
15	17	Female	105	0	Tone
16	8	Male	115	0	Voice
17	12	Female	115	5	Tone
18	18	Male	105	0	Repeated
19	19	Machine	105	0	Repeated
20	20	Female	115	0	Voice
21	21	Machine	105	10	Repeated
22	22	Female	105	0	Voice
23	24	Female	115	5	Voice
24	23	Male	105	5	Tone
25	25	Male	115	10	Repeated
26	26	Machine	105	10	Tone
27	27	Female	115	0	Repeated
28	28	Machine	115	10	Tone
29	29	Machine	115	5	Repeated
30	32	Male	105	10	Repeated
31	30	Female	115	0	Tone
32	31	Male	115	5	Repeated
33	35	Male	105	10	Voice
34	37	Female	105	10	Tone
35	33	Machine	115	5	Voice

RUN SEQUENCE NUMBER	RUN PARAMETER	VOICE TYPE	BACKGROUND NOISE (db)	S/N RATIO (db)	PRECURSOR TYPE
36	34	Machine	115	10	Repeated
37	39	Male	105	0	Tone
38	41	Female	105	5	Voice
39	36	Male	115	0	Tone
40	38	Female	115	10	Voice
41	42	Female	105	5	Tone
42	43	Machine	105	5	Tone
43	44	Male	105	5	Voice
44	45	Machine	115	10	Voice
45	40	Female	115	5	Repeated
46	48	Machine	105	10	Voice
47	46	Female	115	10	Tone
48	47	Machine	115	0	Repeated
49	49	Machine	105	5	Repeated
50	50	Machine	105	5	Voice
51	51	Male	115	10	Voice
52	52	Male	105	5	Repeated
53	53	Male	105	0	Voice
54	54	Female	105	0	Repeated

APPENDIX B3

INSTRUCTIONS TO SUBJECTS

The results of this experiment will be used to help develop cockpit voice warning systems for tactical aircraft (fighters). The experiment consists of 54 runs, each lasting about 35 minutes. Testing is expected to take about 2 1/2 weeks.

The experiment uses two tasks: a primary task associated with the display, and a secondary task associated with the number pad. The primary task consists of pressing the display button nearest a light appearing on the display (see figure 1). It may help to think of the display being divided into eight sections, left and right halves of the display being divided into four rows each (top, upper middle, lower middle, and bottom). For an example, when a light appears anywhere in the bottom left section, press button 4; if it appears in the upper middle right section, press button 6, and so on.

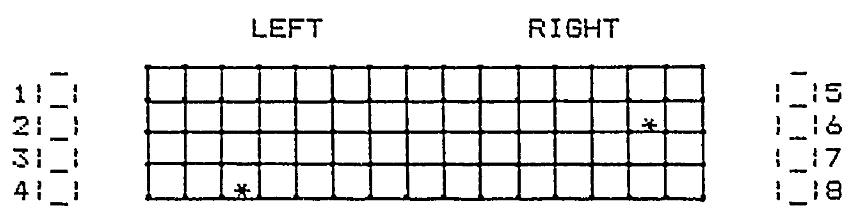

Figure 1. *Top Panel*

The light may appear in different areas of each section, and the lighted section will be changing rapidly. It will be necessary to work quickly and it may help to use two hands.

At random times during each run, a voice over the headphones will announce the side, color, and number of a button on the number pad (see figure 2).

	LEFT				RIGHT				
Red	1	2	3	4	1	2	3	4	Red
Blue	1	2	3	4	1	2	3	4	Blue
White	1	2	3	4	1	2	3	4	White
Grey	1	2	3	4	1	2	3	4	Grey

Figure 2. *Number Pad*

Quickly press the designated button as rapidly as possible. While responding to the voice alert as rapidly as possible do not neglect the primary task. Think of a pilot who must take corrective action during a flight emergency (the secondary task), yet must continue to fly the aircraft (the primary task).

It is expected that some people will do better than others and that techniques will differ. During the practice runs, try several different methods or strategies for accomplishing both tasks: for example use one hand, use two hands, always respond to the voice alert with the same hand, respond to the voice alert with different hands, etc. During the practice period try to determine which method or strategy works best for you. After selecting the method or strategy, practice trying to gain experience with it during the remainder of the practice period. Once the practice period is over do not change methods or strategies. After selecting the technique which is most comfortable, use that same technique for all of the runs.

APPENDIX C

AUTHOR GENERATED PROGRAMS

APPENDIX C1

CONSRAW

```
PROGRAM CONSRAW (INPUT/, OUTPUT, SRAWTOT, C1FIL,SUBFIL,GPFIL, SDAT);

(* READS "SRAWTOT"                                                    *)
(* MANIPULATES DATA, AND OUTPUTS TO MANY FILES                        *)

(*===================================================================*)
(* NOTE.....                                                          *)
(*      TO CUSTOMIZE INPUT, RESET THE CONSTANT "R" (NUMER OF RUNS)    *)
(* IN THE "SETUP" PROCEDURE.                                          *)
(*      TO CUSTOMIZE OUTPUT, MERELY DELETE THE CALL FOR A PARTICULAR *)
(* OUTPUT PROCEDURE IN THE LAST SECTION OF THE PROGRAM.               *)
(*===================================================================*)

(* FOR FORMAT OF INPUT & OUTPUT FILES, SEE "FILE CONVENTIONS" FILE   *)

(*******************************************************************)

(*PSEUDO CODE:                                                        *)
(*      Set up files and variables                                    *)
(*      Read input [SRAWTOT]                                          *)
(*      Do data manipulations                                         *)
(*      **For each run, do:                                           *)
(*        *For each subject,do:                                       *)
(*          Calculate primary task [overall-baseline] figures         *)
(*          Calculate accuracies [percentages]                        *)
(*            (primary, overall, baseline, reduction, percent-BL)     *)
(*          Compare warning-responses to correct responses            *)
(*              Assign "Flag Codes" [1,0,8] to responses              *)
(*              Create time-response array [matrix]                   *)
(*              Calculate accuracy (percent) and average time         *)
(*        *For Group, calculate:                                      *)
(*          Primary task baseline accuracy,                           *)
(*          Primary accuracy,                                         *)
(*          Primary reduction,                                        *)
(*          Primary percentage of baseline,                           *)
(*          Warning task accuracy,                                    *)
(*          Warning mean reasponse-time [for correct responses only] *)
(*      Write output [C1FIL,SUBFIL,GPFIL,SDAT]                     *)

(*******************************************************************)

CONST

    BLANK = ' ';
    WARNSUM = 32;
    S = 10; (* S = NUMBER OF SUBJECTS FOR EACH RUN *)
    R = 54; (* R = NUMBER OF RUNS IN SRAWTOT *)
```

```
TYPE

    INTARRAY = ARRAY [1..R, 1..S] OF INTEGER;
    REALARRAY = ARRAY [1..R, 1..S] OF REAL;
    RUNARRAY = ARRAY [1..R] OF REAL;

    REACTREC = RECORD
        RESPONSE : INTEGER;
        RESPTIME : REAL;
    END; (*REACTREC*)

    LINEREC = RECORD
        LINENUM : INTEGER;
        ANSWER : ARRAY [1..8] OF REACTREC;
    END; (*LINEREC*)

    SUBJECTREC = RECORD
        FIRSLINENUM : INTEGER;
        SUBNUM : INTEGER;
        TRAKTOT : INTEGER;
        TRAKCORR : INTEGER;
        BLTOT : INTEGER;
        BLCORR : INTEGER;
        REACTION : ARRAY [1..4] OF LINEREC;

    END; (*SUBJECTREC*)

    TIMEREC = RECORD
        YEAR : INTEGER;
        MONTH : INTEGER;
        DATE : INTEGER;
        HOUR : INTEGER;
        MINUTE : INTEGER;
        SECOND : INTEGER;
    END; (*TIMEREC *)

    RUNREC = RECORD
        RECLINENUM : INTEGER;
        RUNSEQNUM : INTEGER;
        TIMEDAT : TIMEREC;
        RUNPAR : INTEGER;
        VTYPE : CHAR;
        BKGRD : INTEGER;
        SIGNOISE : INTEGER;
        PRECURS : CHAR;
        STIMULUS : ARRAY [1..32] OF INTEGER;
        SUBDAT : ARRAY [1..S]  OF SUBJECTREC;
    END; (* RUNREC *)
```

```
VAR

    SRAWTOT, C1FIL : TEXT;
    SUBFIL, GPFIL : TEXT;
    SDAT : TEXT;

    STIMRESP : ARRAY [1..R, 1..S, 1..32] OF INTEGER;
    WARNRESP : ARRAY [1..R, 1..S, 1..32] OF INTEGER;
    WARNTIME : ARRAY [1..R, 1..S, 1..32] OF REAL;
    RUNDAT : ARRAY [1..R] OF RUNREC;

    G, H, I, J, K, L, M, N : INTEGER;
    STIMNUM : INTEGER;

    PRTOT, PRCORR : INTARRAY;
    GPPRTOT, GPPRCORR, GPBLTOT, GPBLCORR : ARRAY [1..R] OF INTEGER;

    WARNCORR, NORESPSUM : INTARRAY;
    GPWARNSUM, GPWARNCORR, GPNORESPSUM : ARRAY [1..R] OF INTEGER;

    WARNACC, BLTRACC, PRTRACC, PRACCLOSS, PRPERCBL : REALARRAY;
    MNRESPTIME, TIMESUM : REALARRAY;
    GPBLTRACC, GPPRTRACC, GPPRACCLOSS, GPPRPERCBL : RUNARRAY;
    GPMNWARNCORR, GPWARNACC, GPMNRESPTIME : RUNARRAY;
    GPTIMESUM, GPMNNORESPSUM : RUNARRAY;

    SPACER : CHAR;


(*******************************************************************)

PROCEDURE SETUP;

(*PSEUDO CODE:                                                     *)
(*      Set up files                                               *)
(*          Reset input files                                      *)
(*          Rewrite output files                                   *)
(*      Initialize variables for summing                           *)
(*.................................................................*)

BEGIN

    RESET (SRAWTOT);
    REWRITE (C1FIL);
    REWRITE (SUBFIL);
    REWRITE (GPFIL);
    REWRITE (SDAT);

    FOR M := 1 TO R DO BEGIN
```

```
        (* PRIMARY TASK SUMS *)

        GPPRTOT[M] := 0;
        GPPRCORR[M] := 0;
        GPBLTOT[M] := 0;
        GPBLCORR[M] := 0;

        (* SECONDARY TASK SUMS *)

        FOR I := 1 TO 5 DO BEGIN
            TIMESUM[M,I] := 0.0;
            WARNCORR[M,I] := 0;
            NORESPSUM[M,I] := 0;
        END; (*FOR I...BEGIN *)
        GPWARNSUM[M] := 0;
        GPWARNCORR[M] := 0;
        GPNORESPSUM[M] := 0;
        GPTIMESUM[M] := 0.0;
    END; (* FOR M...BEGIN *)
END; (* SETUP *)

(**********************************************************************)

PROCEDURE READITIN;

(*PSEUDO CODE                                                         *)
(*  For each run, do:                                                 *)
(*      Read record 00                                                *)
(*      Read 32 "warning" stimuli into (STIMULUS)                     *)
(*      For each subject do                                           *)
(*          Read five-record set [must read field-by-field]           *)
(*          Format into proper array information                      *)
(*....................................................................*)

BEGIN

  FOR M := 1 TO R DO BEGIN
   WITH RUNDAT[M] DO BEGIN
    READ (SRAWTOT, RECLINENUM, RUNSEQNUM);
    WITH TIMEDAT DO
      READ (SRAWTOT, YEAR, MONTH, DATE, HOUR, MINUTE,
            SECOND);
    READ (SRAWTOT, RUNPAR, SPACER, VTYPE, BKGRD, SIGNOISE,
          SPACER, PRECURS);
    READLN (SRAWTOT);

    (* CHECKS THAT RUNS ARE ENTERED IN ORDER BY COMPARING RUNSEQNUM *)
    (* WITH PREVIOUS RUNSEQNUM, AND PRINTS WARNING ON SCREEN        *)
    IF M > 1 THEN BEGIN
    G := M -1;
    IF RUNSEQNUM <> RUNDAT[G].RUNSEQNUM + 1 THEN
      WRITELN ('NOTE: RUN SEQUENCE', RUNSEQNUM,' LISTED OUT OF ORDER');
    END; (* IF M *)
```

```
    READ (SRAWTOT, RECLINENUM);
    FOR I := 1 TO 16 DO
        READ (SRAWTOT, STIMULUS[I]);
    READLN (SRAWTOT);
    READ (SRAWTOT, RECLINENUM);
    FOR I := 17 TO 32 DO
        READ (SRAWTOT, STIMULUS[I]);
    READLN (SRAWTOT);

  (* READ WARNING RESPONSE DATA FOR EACH SUBJECT *)
    FOR J := 1 TO S DO BEGIN
        N := 1; (* RESETS STIMULUS NUMBER *)
        WITH SUBDAT[J] DO BEGIN
            READ (SRAWTOT, FIRSLINENUM, SUBNUM, TRAKTOT, TRAKCORR,
                  BLTOT, BLCORR);
            READLN (SRAWTOT);
            FOR K := 1 TO 4 DO BEGIN
                WITH REACTION[K] DO BEGIN
                    READ (SRAWTOT, LINENUM);
                    FOR L := 1 TO 8 DO BEGIN
                        WITH ANSWER[L] DO BEGIN
                            READ (SRAWTOT, RESPONSE, RESPTIME);
                          (* ASSIGNS DATA TO NEW ARRAYS *)
                            STIMRESP[M,J,N] := RESPONSE;
                            WARNTIME[M,J,N] := RESPTIME;
                            IF RESPONSE = STIMULUS[N] THEN
                                WARNRESP[M,J,N] := 1
                            ELSE IF RESPONSE = 33 THEN
                                WARNRESP[M,J,N] := 8
                            ELSE IF RESPONSE = 99 THEN
                                WARNRESP[M,J,N] := 8
                            ELSE WARNRESP[M,J,N] := 0;
                        N := N + 1;  (* UPDATES WARNING NUMBER *)
                        END; (* WITH ANSWER...BEGIN *)
                    END; (* FOR L...BEGIN *)
                    READLN (SRAWTOT);
                END; (* WITH REACTON...BEGIN *)
            END; (* FOR K...BEGIN *)
        END; (* WITH SUBDAT...BEGIN *)
    END; (* FOR J...BEGIN *)
   END; (* WITH RUNDAT...BEGIN *)
  END; (* FOR M...BEGIN *)

END; (*READITIN*)

(**********************************************************************)

PROCEDURE CALCULATE;
```

```
(*PSEUDO CODE                                                         *)
(*   For each run, do:                                                *)
(*      For each subject, calculate:                                  *)
(*          Primary (tracking) task:                                  *)
(*              Primary (Non-BASELINE) stimuli & responses            *)
(*              Baseline accuracy (percentage)                        *)
(*              Primary accuracy                                      *)
(*              Accuracy loss [baseline minus primary]                *)
(*              Primary percent of peak performance (i.e.,BASELINE)   *)
(*                  [Primary divided by Baseline]                     *)
(*          Secondary (warning) task:                                 *)
(*              Number of correct responses                           *)
(*              Number of "No-response within allotted time"          *)
(*              Percent correct responses                             *)
(*              Mean response time (correct responses only)           *)
(*      For the Group (for each run), calculate                       *)
(*          Primary task:                                             *)
(*              Mean primary accuracy                                 *)
(*              Mean baseline accuracy                                *)
(*              Mean accuracy loss                                    *)
(*              Mean percent of peak performance                      *)
(*          Secondary task:                                           *)
(*              Mean number of correct reponses                       *)
(*              Mean number of "no-responses within allotted time"    *)
(*              Mean accuracy                                         *)
(*              Mean response time                                    *)
(*.....................................................................*)


BEGIN

 (* FOR EACH RUN *)
 FOR M := 1 TO R DO BEGIN
  WITH RUNDAT[M] DO BEGIN

     (* FOR EACH SUBJECT: *)
    FOR J := 1 TO S DO BEGIN

       (* CALCULATES PRIMARY [NON-BASELINE] PERFORMANCE *)
       PRTOT[M,J] := SUBDAT[J].TRAKTOT - SUBDAT[J].BLTOT;
       PRCORR[M,J] := SUBDAT[J].TRAKCORR - SUBDAT[J].BLCORR;

       (* CALCULATES ACCURACY *)
       BLTRACC[M,J] := SUBDAT[J].BLCORR/SUBDAT[J].BLTOT;
       PRTRACC[M,J] := PRCORR[M,J]/PRTOT[M,J];

       (* ACCURACY LOSS *)
       PRACCLOSS[M,J] := BLTRACC[M,J] - PRTRACC[M,J];

       (* PERCENTAGE OF PEAK [BASELINE] PERFORMANCE *)
       PRPERCBL[M,J] := PRTRACC[M,J]/BLTRACC[M,J];
```

```
        (* SECONDARY [WARNING] TASK PERFORMANCE *)

        (* RESETS SUMS TO ZERO FOR EACH SUBJECT *)
        WARNCORR[M,J] := 0;
        NORESPSUM[M,J] := 0;
        TIMESUM[M,J] := 0.0;

        FOR N := 1 TO 32 DO BEGIN
            CASE WARNRESP[M,J,N] OF
                1 : BEGIN
                        WARNCORR[M,J] := WARNCORR[M,J] + 1;
                        TIMESUM[M,J] := TIMESUM[M,J] + WARNTIME[M,J,N];
                    END; (* CASE 1 [CORRECT RESPONSE] *)
                0 : ; (* NO UPDATES [INCORRECT RESPONSE] *)
                8 : NORESPSUM[M,J] := NORESPSUM[M,J] + 1; (* NO RESPONSE *)
            END; (* CASE *)
        END; (* FOR N...BEGIN *)

        (* COMPUTES ACCURACY & MEAN RESPONSE TIME FOR CORRECT ANSWERS *)
        WARNACC[M,J] := WARNCORR[M,J]/32;
        MNRESPTIME[M,J] := TIMESUM[M,J]/WARNCORR[M,J];

        (* NOTE: GROUP SUMS WERE RESET TO ZERO IN PROCEDURE "SETUP" *)
        (* UPDATES GROUP SUMS *)
        GPPRTOT[M] := GPPRTOT[M] + PRTOT[M,J];
        GPPRCORR[M] := GPPRCORR[M] + PRCORR[M,J];
        GPBLTOT[M] := GPBLTOT[M] + SUBDAT[J].BLTOT;
        GPBLCORR[M] := GPBLCORR[M] + SUBDAT[J].BLCORR;
        GPWARNSUM[M] := GPWARNSUM[M] + 32;
        GPWARNCORR[M] := GPWARNCORR[M] + WARNCORR[M,J];
        GPTIMESUM[M] := GPTIMESUM[M] + TIMESUM[M,J];
        GPNORESPSUM[M] := GPNORESPSUM[M] + NORESPSUM[M,J];

     END; (* FOR J...BEGIN *)
   END; (* WITH RUNDAT...BEGIN *)

    (* CALCULATES GROUP PERFORMANCE *)

    (* PRIMARY [TRACKING] TASK *)
    GPPRTRACC[M] := GPPRCORR[M]/GPPRTOT[M];
    GPBLTRACC[M] := GPBLCORR[M]/GPBLTOT[M];
    GPPRACCLOSS[M] := GPBLTRACC[M] - GPPRTRACC[M];
    GPPRPERCBL[M] := GPPRTRACC[M]/GPBLTRACC[M];

    (* SECONDARY [WARNING] RESPONSE *)
    GPMNWARNCORR[M] := GPWARNCORR[M]/S;
    GPWARNACC[M] := GPMNWARNCORR[M]/32;
    GPMNRESPTIME[M] := GPTIMESUM[M]/GPWARNCORR[M];
    GPMNNORESPSUM[M] := GPNORESPSUM[M]/S;
 END; (* FOR M...BEGIN *)
END; (* CALCULATE *)
```

```
(*****************************************************************************)

PROCEDURE WRITITOUT;

(*PSEUDO CODE                                                                *)
(*  For each run, do:                                                        *)
(*    Write output to "C1FIL":                                               *)
(*      Writes run-identifiers                                               *)
(*      For each subject writes:                                             *)
(*          Response "flags" [1=correct, 0=incorrect, 8=no response] *)
(*          Response times [ 4 lines @ 10-10-10-2 ]                          *)
(*      For each subject, writes summary performance information     *)
(*      For group, writes mean performance information for this run  *)
(*...........................................................................*)

BEGIN

  FOR M:= 1 TO R DO BEGIN

    WITH RUNDAT[M] DO
      WRITELN (C1FIL, RUNSEQNUM:3, RUNPAR:3, BLANK, VTYPE, BKGRD:4,
             SIGNOISE:3, BLANK, PRECURS);

    (*  WRITES SUBJECT NUMBER AND CORRECT-RESPONSE FLAGS  *)

    FOR J := 1 TO S DO BEGIN
        WRITE (C1FIL, RUNDAT[M].RUNSEQNUM:2, J:3);
        FOR I := 1 TO 32 DO
            WRITE (C1FIL, WARNRESP[M,J,I]:2);
        WRITELN (C1FIL);
    END; (* FOR J...BEGIN *)

(*  WRITES RESPONSE TIMES FOR EACH SUBJECT  *)

    FOR J := 1 TO S DO BEGIN
        WRITE (C1FIL, RUNDAT[M].RUNSEQNUM:2,J:3);
        FOR N := 1 TO 10 DO
            WRITE (C1FIL, WARNTIME[M,J,N]:7:3);
        WRITELN (C1FIL);
        WRITE (C1FIL, RUNDAT[M].RUNSEQNUM:2, J:3);
        FOR N := 11 TO 20 DO
            WRITE (C1FIL, WARNTIME[M,J,N]:7:3);
        WRITELN (C1FIL);
        WRITE (C1FIL, RUNDAT[M].RUNSEQNUM:2, J:3);
        FOR N := 21 TO 30 DO
            WRITE (C1FIL, WARNTIME[M,J,N]:7:3);
        WRITELN (C1FIL);
        WRITE (C1FIL, RUNDAT[M].RUNSEQNUM:2, J:3);
        FOR N := 31 TO 32 DO
            WRITE (C1FIL, WARNTIME[M,J,N]:7:3);
        WRITELN (C1FIL);
    END; (* FOR J...BEGIN *)
```

```
(*  WRITES PERFORMANCE SUMMARY FOR EACH SUBJECT IN THIS RUN  *)

    FOR J := 1 TO S DO BEGIN

    WITH RUNDAT[M] DO
        WRITE (C1FIL, RUNSEQNUM:3, RUNPAR:3, BLANK, VTYPE,
                 BKGRD:4, SIGNOISE:3, BLANK, PRECURS);

        WRITELN (C1FIL, J:5, BLTRACC[M,J]:6:3,
                 PRTRACC[M,J]:6:3, PRACCLOSS[M,J]:6:3,
                 PRPERCBL[M,J]:6:3, WARNCORR[M,J]:3, NORESPSUM[M,J]:3,
                 WARNACC[M,J]:6:3, MNRESPTIME[M,J]:6:3);


   END; (* FOR J...BEGIN *)

(*  WRITES GROUP PERFORMANCE FOR THIS RUN  *)

  WITH RUNDAT[M] DO
    WRITE (C1FIL, RUNSEQNUM:3, RUNPAR:2, SPACER, VTYPE, BKGRD:4,
            SIGNOISE:3, SPACER, PRECURS);
    WRITELN (C1FIL, GPBLTRACC[M]:6:3, GPPRTRACC[M]:6:3,
            GPPRACCLOSS[M]:6:3, GPPRPERCBL[M]:6:3, GPMNWARNCORR[M]:8:3,
            GPMNNORESPSUM[M]:6:3, GPWARNACC[M]:6:3, GPMNRESPTIME[M]:6:3);


  END; (* FOR M...BEGIN *)

END; (*WRITITOUT*)

(**********************************************************************)

PROCEDURE WRITESUBDAT;

(*PSEUDO CODE                                                        *)
(*   Write output to "SUBFIL":                                       *)
(*    For each run:                                                  *)
(*      Write run parameter information                              *)
(*      For each subject, writes summary performance information     *)
(*...................................................................*)


BEGIN

  FOR M:= 1 TO R DO BEGIN

    FOR J := 1 TO S DO BEGIN
        (* WRITES SUBJECT DATA TO "SUBFIL" *)

    WITH RUNDAT[M] DO
        WRITE (SUBFIL, RUNSEQNUM:3, RUNPAR:3, BLANK, VTYPE.
                 BKGRD:4, SIGNOISE:3, BLANK, PRECURS);
```

```
        WRITELN (SUBFIL, J:5, BLTRACC[M,J]:6:3,
                 PRTRACC[M,J]:6:3, PRACCLOSS[M,J]:6:3,
                 PRPERCBL[M,J]:6:3, WARNCORR[M,J]:3,  NORESPSUM[M,J]:3,
                 WARNACC[M,J]:6:3, MNRESPTIME[M,J]:6:3);

    END; (* FOR J...BEGIN *)

  END; (* FOR M...BEGIN *)

END; (* WRITESUBDAT *)


(******************************************************************)

PROCEDURE WRITEGPDAT;

(*PSEUDO CODE                                                    *)
(*    Write output to "GPFIL":                                   *)
(*      For group, writes mean performance information for each run  *)
(*...............................................................*)

BEGIN

  FOR M:= 1 TO R DO BEGIN

   (* WRITES GROUP DATA TO "GPFIL" *)
   WITH RUNDAT[M] DO
     WRITE (GPFIL, RUNSEQNUM:3, RUNPAR:2, SPACER, VTYPE, BKGRD:4,
            SIGNOISE:3, SPACER, PRECURS);
     WRITELN (GPFIL, GPBLTRACC[M]:6:3, GPPRTRACC[M]:6:3,
            GPPRACCLOSS[M]:6:3, GPPRPERCBL[M]:6:3, GPMNWARNCORR[M]:8:3,
            GPMNNORESPSUM[M]:6:3, GPWARNACC[M]:6:3, GPMNRESPTIME[M]:6:3);

  END; (* FOR M...BEGIN *)

END; (* WRITEGPDAT *)

(******************************************************************)

PROCEDURE WRITSDAT;

(* PSEUDO CODE:                                                  *)
(*  Writes data to "SDAT", for use by the SPSS program           *)
(*  **For each run, do:                                          *)
(*    **For each subject, do:                                    *)
(*      **For each stimulus, do:                                 *)
(*         Write (one line per stimulus):                        *)
(*          Run sequence number                                  *)
(*          Voice type                                           *)
(*          Background engine noise level                        *)
(*          Signal-to-noise ratio over headset                   *)
```

```
(*        Precursor type                                                  *)
(*        Subject number                                                  *)
(*        Stimulus sequence number [1 to 31, in order]                    *)
(*        Stimulus given [button number, 1 to 31]                         *)
(*        Response to stimulus[1 to 32, or 99 for no response]            *)
(*        Stimulus response code [1,0,8]                                  *)
(*        Response time for that stimulus                                 *)
(*        Baseline Primary task tracking accuracy for this subj/run*)
(*        Primary individually-normalized accuracy for this sub/run*)
(*.....................................................................*)

BEGIN

  FOR M := 1 TO R DO BEGIN                (* FOR EACH RUN *)
    FOR J := 1 TO S DO BEGIN              (* FOR EACH SUBJECT *)
      FOR I := 1 TO 32 DO BEGIN           (* FOR EACH STIMULUS *)

        STIMNUM := I;

        WITH RUNDAT[M] DO
          WRITE (SDAT, RUNSEQNUM:3, SPACER, VTYPE, BKGRD:4, SIGNOISE:3,
                 SPACER, PRECURS, SUBDAT[J].SUBNUM:3,
                 STIMNUM:3, STIMULUS[I]:3);

        WRITE (SDAT, STIMRESP[M,J,I]:3, WARNRESP[M,J,I]:3,
               WARNTIME[M,J,I]:7:3, BLTRACC[M,J]:7:3,
               PRPERCBL[M,J]:7:3);

        WRITELN (SDAT);

      END; (* FOR I...BEGIN *)
    END; (* FOR J...BEGIN *)
  END; (* FOR M...BEGIN *)


END; (* WRITSDAT *)

(*********************************************************************)


BEGIN
        SETUP;
        READITIN;
        CALCULATE;
        WRITITOUT;
        WRITESUBDAT;
        WRITEGPDAT;
        WRITSDAT;
END.
```

APPENDIX C2

TTEST1

```
PROGRAM TTEST1 (INPUT/, OUTPUT, SRAWTOT, TFIL);

(* READS "SRAWTOT"                                                  *)
(* COMPUTES T-TEST DATA, AND OUTPUTS TO "TFIL"                      *)

(*=================================================================*)
(* NOTE.....                                                        *)
(*      TO CUSTOMIZE INPUT, RESET THE CONSTANT "R" (NUMER OF RUNS)  *)
(* IN THE "SETUP" PROCEDURE.                                        *)
(*=================================================================*)

(* FOR FORMAT OF INPUT & OUTPUT FILES, SEE "FILE CONVENTIONS" FILE  *)

(*******************************************************************)

(*PSEUDO CODE:                                                      *)
(*      Set up files and variables                                  *)
(*      Read input [SRAWTOT]                                        *)
(*      Do data manipulations                                       *)
(*      **For each run, do:                                         *)
(*        *For each subject,do:                                     *)
(*          Calculate primary task [overall-baseline] figures       *)
(*          Calculate accuracies [percentages]                      *)
(*            (primary, overall, baseline, reduction, percent-BL)   *)
(*          Compare warning-responses to correct responses          *)
(*              Assign "Flag Codes" [1,0,8] to responses            *)
(*              Create time-response array [matrix]                 *)
(*              Calculate accuracy (percent) and average time       *)
(*        *For Group, calculate:                                    *)
(*              First 1/3rd (stimuli 1-11) accuracy and speed       *)
(*              Last 1/3rd (stimuli 22-32) accuracy and speed       *)
(*        *Perform grouped t-test between first and last 1/3rd data *)
(*      Write output [TFIL]                                         *)

(*******************************************************************)

CONST

    BLANK = ' ';
    WARNSUM = 32;
    S = 10; (* S = NUMBER OF SUBJECTS FOR EACH RUN *)
    R = 54; (* R = NUMBER OF RUNS IN SRAWTOT *)
    TCRIT = 2.101;  (* "t" for 18 d.f., F=.975 [2-sided .05 alpha] *)

TYPE

    TINTARRAY = ARRAY [1..R, 1..S, 1..2] OF INTEGER;
    TREALARRAY = ARRAY [1..R, 1..S, 1..2] OF REAL;
    RUNINTARRAY = ARRAY [1..R, 1..2] OF INTEGER;
    RUNREALARRAY = ARRAY [1..R, 1..2] OF REAL;
```

```
    REACTREC = RECORD
        RESPONSE : INTEGER;
        RESPTIME : REAL;
    END; (*REACTREC*)

    LINEREC = RECORD
        LINENUM : INTEGER;
        ANSWER : ARRAY [1..8] OF REACTREC;
    END; (*LINEREC*)

    SUBJECTREC = RECORD
        FIRSLINENUM : INTEGER;
        SUBNUM : INTEGER;
        TRAKTOT : INTEGER;
        TRAKCORR : INTEGER;
        BLTOT : INTEGER;
        BLCORR : INTEGER;
        REACTION : ARRAY [1..4] OF LINEREC;

    END; (*SUBJECTREC*)

    TIMEREC = RECORD
        YEAR : INTEGER;
        MONTH : INTEGER;
        DATE : INTEGER;
        HOUR : INTEGER;
        MINUTE : INTEGER;
        SECOND : INTEGER;
    END; (*TIMEREC *)

    RUNREC = RECORD
        RECLINENUM : INTEGER;
        RUNSEQNUM : INTEGER;
        TIMEDAT : TIMEREC;
        RUNPAR : INTEGER;
        VTYPE : CHAR;
        BKGRD : INTEGER;
        SIGNOISE : INTEGER;
        PRECURS : CHAR;
        STIMULUS : ARRAY [1..32] OF INTEGER;
        SUBDAT : ARRAY [1..S]  OF SUBJECTREC;
    END; (* RUNREC *)

VAR

    SRAWTOT, TFIL : TEXT;

    G, H, I, J, K, L, M, N : INTEGER;
    STIMNUM : INTEGER;

    WV1, WV2, TV1, TV2, ADJ : REAL;
    DENWARN, DENTIME : REAL;
```

```
    STIMRESP : ARRAY [1..R, 1..S, 1..32] OF INTEGER;
    WARNRESP : ARRAY [1..R, 1..S, 1..32] OF INTEGER;
    WARNTIME : ARRAY [1..R, 1..S, 1..32] OF REAL;
    RUNDAT : ARRAY [1..R] OF RUNREC;

    TWARN : ARRAY [1..R] OF REAL;
    TTIME : ARRAY [1..R] OF REAL;


    WARNCORR, GPWARNSUM : TINTARRAY;

    WARNACC, MNRESPTIME, TIMESUM : TREALARRAY;

    WDIF, TDIF, WDIFSQ, TDIFSQ : TREALARRAY;

    GPWARNACCSUM, GPMNWARNACC : RUNREALARRAY;

    GPTIMESUM, GPMNRESPTIME : RUNREALARRAY;

    WARNVAR, TIMEVAR : RUNREALARRAY;

    SUMWDIFSQ, SUMTDIFSQ : RUNREALARRAY;

    SPACER : CHAR;


(***********************************************************************)

PROCEDURE SETUP;

(*PSEUDO CODE:                                                         *)
(*      Set up files                                                   *)
(*          Reset input files                                          *)
(*          Rewrite output files                                       *)
(*      Initialize variables for summing                               *)
(*.....................................................................*)

BEGIN

    RESET (SRAWTOT);
    REWRITE (TFIL);

    FOR M := 1 TO R DO BEGIN

      (* SUBJECT SUMS *)
        FOR I := 1 TO S DO BEGIN

            TIMESUM[M,I,1] := 0.0;
            TIMESUM[M,I,2] := 0.0;
```

```
            WARNCORR[M,I,1] := 0;
            WARNCORR[M,I,2] := 0;

        END; (*FOR I...BEGIN *)

      (* GROUP SUMS *)

        GPWARNACCSUM[M,1] := 0.0;
        GPWARNACCSUM[M,2] := 0.0;

        GPTIMESUM[M,1] := C 0;
        GPTIMESUM[M,2] := 0.0;

        SUMWDIFSQ[M,1] := 0.0;
        SUMWDIFSQ[M,2] := 0.0;

        SUMTDIFSQ[M,1] := 0.0;
        SUMTDIFSQ[M,2] := 0.0;

    END; (* FOR M...BEGIN *)

END; (* SETUP *)

(************************************************************************)

PROCEDURE READITIN;

(*PSEUDO CODE                                                           *)
(*  For each run, do:                                                   *)
(*      Read record 00                                                  *)
(*      Read 32 "warning" stimuli into (STIMULUS)                       *)
(*      For each subject do                                             *)
(*          Read five-record set [must read field-by-field]             *)
(*          Format into proper array information                        *)
(*......................................................................*)

BEGIN

  FOR M := 1 TO R DO BEGIN
   WITH RUNDAT[M] DO BEGIN
    READ (SRAWTOT, RECLINENUM, RUNSEQNUM);
    WITH TIMEDAT DO
      READ (SRAWTOT, YEAR, MONTH, DATE, HOUR, MINUTE,
            SECOND);
    READ (SRAWTOT, RUNPAR, SPACER, VTYPE, BKGRD, SIGNOISE,
          SPACER, PRECURS);
    READLN (SRAWTOT);

    (* CHECKS THAT RUNS ARE ENTERED IN ORDER BY COMPARING RUNSEQNUM *)
    (* WITH PREVIOUS RUNSEQNUM, AND PRINTS WARNING ON SCREEN        *)
```

```
 IF M > 1 THEN BEGIN
 G := M -1;
 IF RUNSEQNUM <> RUNDAT[G].RUNSEQNUM + 1 THEN
   WRITELN ('NOTE: RUN SEQUENCE', RUNSEQNUM,' LISTED OUT OF ORDER');
 END; (* IF M *)

 READ (SRAWTOT, RECLINENUM);
 FOR I := 1 TO 16 DO
     READ (SRAWTOT, STIMULUS[I]);
 READLN (SRAWTOT);
 READ (SRAWTOT, RECLINENUM);
 FOR I := 17 TO 32 DO
     READ (SRAWTOT, STIMULUS[I]);
 READLN (SRAWTOT);

(* READ WARNING RESPONSE DATA FOR EACH SUBJECT *)
 FOR J := 1 TO S DO BEGIN
     N := 1; (* RESETS STIMULUS NUMBER *)
     WITH SUBDAT[J] DO BEGIN
         READ (SRAWTOT, FIRSLINENUM, SUBNUM, TRAKTOT, TRAKCORR,
               BLTOT, BLCORR);
         READLN (SRAWTOT);
         FOR K := 1 TO 4 DO BEGIN
             WITH REACTION[K] DO BEGIN
                 READ (SRAWTOT, LINENUM);
                 FOR L := 1 TO 8 DO BEGIN
                     WITH ANSWER[L] DO BEGIN
                         READ (SRAWTOT, RESPONSE, RESPTIME);
                       (* ASSIGNS DATA TO NEW ARRAYS *)
                         STIMRESP[M,J,N] := RESPONSE;
                         WARNTIME[M,J,N] := RESPTIME;
                        (* ASSIGNS 1=CORRECT, 0=INCORRECT OR MISSING *)
                         IF RESPONSE = STIMULUS[N] THEN
                              WARNRESP[M,J,N] := 1
                         ELSE WARNRESP[M,J,N] := 0;
                     N := N + 1;  (* UPDATES WARNING NUMBER *)
                     END; (* WITH ANSWER...BEGIN *)
                 END; (* FOR L...BEGIN *)
                 READLN (SRAWTOT);
             END; (* WITH REACTON...BEGIN *)
         END; (* FOR K...BEGIN *)
     END; (* WITH SUBDAT...BEGIN *)
 END; (* FOR J...BEGIN *)
END; (* WITH RUNDAT...BEGIN *)
END; (* FOR M...BEGIN *)

END; (*READITIN*)

(**********************************************************************)

PROCEDURE CALCULATE;
```

```
(*PSEUDO CODE                                                          *)
(*   For each run, do:                                                 *)
(*      [For first-1/3rd and last-1/3rd] calculate:                    *)
(*      For each subject:                                              *)
(*          Number of correct responses                                *)
(*          Sum of response times (correct responses only)             *)
(*          Accuracy                                                   *)
(*          Mean response time (correct resp's only)                   *)
(*      [For accuracy and response times] :                            *)
(*      Group means and variances for first & last 1/3rd               *)
(*      Gouped t-test values                                           *)
(*.....................................................................*)

BEGIN

 (* FOR EACH RUN *)
 FOR M := 1 TO R DO BEGIN

     (* FOR EACH SUBJECT: *)
     FOR J := 1 TO S DO BEGIN

         (* SUBJECT SUMS WERE SET TO ZERO IN "SETUP" *)

         (* CALCULATES FIRST-1/3RD DATAPOINT SUMS *)
         FOR N := 1 TO 11 DO BEGIN
             CASE WARNRESP[M,J,N] OF
                 1 : BEGIN
                         WARNCORR[M,J,1] := WARNCORR[M,J,1] + 1;
                         TIMESUM[M,J,1] := TIMESUM[M,J,1] + WARNTIME[M,J,N];
                     END; (* CASE 1 [CORRECT RESPONSE] *)
                 0 : ; (* NO UPDATES [INCORRECT RESPONSE] *)
                 8 : ; (* NO UPDATES [MISSED RESPONSE] *)
             END; (* CASE *)
         END; (* FOR N...BEGIN *)

         (* CALCULATES LAST-1/3RD DATAPOINT SUMS *)
         FOR N := 22 TO 32 DO BEGIN
             CASE WARNRESP[M,J,N] OF
                 1 : BEGIN
                         WARNCORR[M,J,2] := WARNCORR[M,J,2] + 1;
                         TIMESUM[M,J,2] := TIMESUM[M,J,2] + WARNTIME[M,J,N];
                     END; (* CASE 1 [CORRECT RESPONSE] *)
                 0 : ; (* NO UPDATES [INCORRECT RESPONSE] *)
                 8 : ; (* NO UPDATES [MISSED RESPONSE] *)
             END; (* CASE *)
         END; (* FOR N...BEGIN *)
     END;  (* FOR J...BEGIN *)

   (* CALCULATES MEAN PERFORMANCE FOR FIRST- AND LAST- 1/3RD *)
     FOR J:= 1 TO S DO BEGIN
```

```
      WARNACC[M,J,1] := WARNCORR[M,J,1]/11;
      WARNACC[M,J,2] := WARNCORR[M,J,2]/11;

      MNRESPTIME[M,J,1] := TIMESUM[M,J,1]/WARNCORR[M,J,1];
      MNRESPTIME[M,J,2] := TIMESUM[M,J,2]/WARNCORR[M,J,2];

   END; (* FOR J...BEGIN *)
 (* CALCULATES GROUP MEANS AND VARIANCES *)

   (* CALCULATES GROUP SUMS *)

   FOR J := 1 TO S DO BEGIN

     GPWARNACCSUM[M,1] := GPWARNACCSUM[M,1] + WARNACC[M,J,1];
     GPWARNACCSUM[M,2] := GPWARNACCSUM[M,2] + WARNACC[M,J,2];

     GPTIMESUM[M,1] := GPTIMESUM[M,1] + MNRESPTIME[M,J,1];
     GPTIMESUM[M,2] := GPTIMESUM[M,2] + MNRESPTIME[M,J,2];

   END;  (* FOR J...BEGIN *)

   (* CALCULATES GROUP MEANS *)

   GPMNWARNACC[M,1] := GPWARNACCSUM[M,1]/S;
   GPMNWARNACC[M,2] := GPWARNACCSUM[M,2]/S;

   GPMNRESPTIME[M,1] := GPTIMESUM[M,1]/S;
   GPMNRESPTIME[M,2] := GPTIMESUM[M,2]/S;

   (* CALCULATES VARIANCES *)
   FOR J := 1 TO S DO BEGIN

       WDIF[M,J,1] := WARNACC[M,J,1] - GPMNWARNACC[M,1];
       WDIF[M,J,2] := WARNACC[M,J,2] - GPMNWARNACC[M,2];

       TDIF[M,J,1] := MNRESPTIME[M,J,1] - GPMNRESPTIME[M,1];
       TDIF[M,J,2] := MNRESPTIME[M,J,2] - GPMNRESPTIME[M,2];

       WDIFSQ[M,J,1] := SQR(WDIF[M,J,1]);
       WDIFSQ[M,J,2] := SQR(WDIF[M,J,2]);

       TDIFSQ[M,J,1] := SQR(TDIF[M,J,1]);
       TDIFSQ[M,J,2] := SQR(TDIF[M,J,2]);

       SUMWDIFSQ[M,1] := SUMWDIFSQ[M,1] + WDIFSQ[M,J,1];
       SUMWDIFSQ[M,2] := SUMWDIFSQ[M,2] + WDIFSQ[M,J,2];

       SUMTDIFSQ[M,1] := SUMTDIFSQ[M,1] + TDIFSQ[M,J,1];
       SUMTDIFSQ[M,2] := SUMTDIFSQ[M,2] + TDIFSQ[M,J,2];

   END;  (* FOR J...BEGIN *0
```

```
    WARNVAR[M,1] := SUMWDIFSQ[M,1]/S;
    WARNVAR[M,2] := SUMWDIFSQ[M,2]/S;

    TIMEVAR[M,1] := SUMTDIFSQ[M,1]/S;
    TIMEVAR[M,2] := SUMTDIFSQ[M,2]/S;

  (* CALCULATES "T"-VALUE FOR T-TEST *)

    WV1 := WARNVAR[M,1];
    WV2 := WARNVAR[M,2];
    TV1 := TIMEVAR[M,1];
    TV2 := TIMEVAR[M,2];

    ADJ := (S+S)/(S*S);

    DENWARN := SQRT( ( ( (S-1)*WV1 + (S-1)*WV2 ) / (S+S-2) ) * ADJ );

    DENTIME := SQRT( ( ( (S-1)*TV1 + (S-1)*TV2 ) / (S+S-2) ) * ADJ );

    TWARN[M] := ABS(GPMNWARNACC[M,1]-GPMNWARNACC[M,2])/DENWARN;

    TTIME[M] := ABS(GPMNRESPTIME[M,1]-GPMNRESPTIME[M,2])/DENTIME;

 END; (* FOR M...BEGIN *)

END; (* CALCULATE *)


(*****************************************************************)

PROCEDURE WRITETFIL;

(* PSEUDO CODE;                                                  *)
(*   Writes results to file "TFIL"                               *)
(*   Write title lines                                           *)
(*   For each run write:                                         *)
(*          Run sequence number                                  *)
(*          Accuracy for first 1/3rd                             *)
(*          Variance for first 1/3rd accuracv                    *)
(*          Accuracy for last 1/3rd                              *)
(*          Variance for last 1/3rd accuracy                     *)
(*          Mean response time for first 1/3rd                   *)
(*          Variance for first 1/3rd responmse time              *)
(*          Mean response time for last 1/3rd                    *)
(*          Variance for last 1/3rd response time                *)
(*          T-value for accuracy                                 *)
(*          T-value for response time                            *)
(*          Critical t-value for two-tailed test, using          *)
(*              alpha=.05 and 18 degrees of freedom              *)
(*          Indicate if difference is statistically significant  *)
(*...............................................................*)
```

```
BEGIN

    WRITELN (TFIL, 'T-TEST FOR WITHIN-RUN FATIGUE/LEARNING CURVE');
    WRITE (TFIL,' RN ACC-1 VACC1 ACC-2 VACC2 TIME-1 VTIM1 TIME-2 VTIM2');
    WRITE (TFIL, ' TWARN TTIME TCRIT CRIT?');
    WRITELN (TFIL);
    WRITE (TFIL,' == ===== ===== ===== ===== ====== ===== ====== =====');
    WRITE (TFIL, ' ===== ===== ===== == ==');
    WRITELN (TFIL);
    WRITELN (TFIL);


    FOR M := 1 TO R DO BEGIN


            WRITE (TFIL, RUNDAT[M].RUNSEQNUM:3,
                        GPMNWARNACC[M,1]:6:3, WARNVAR[M,1]:6:3,
                        GPMNWARNACC[M,2]:6:3, WARNVAR[M,2]:6:3,
                        GPMNRESPTIME[M,1]:7:3, TIMEVAR[M,1]:6:3,
                        GPMNRESPTIME[M,2]:7:3, TIMEVAR[M,2]:6:3,
                        TWARN[M]:6:3, TTIME[M]:6:3, TCRIT:6:3);
            IF TWARN[M] >= TCRIT THEN
                WRITE (TFIL, ' W')
            ELSE WRITE (TFIL, '  ');
            IF TTIME[M] >= TCRIT THEN
                WRITE (TFIL, ' T')
            ELSE WRITE (TFIL, '  ');

            WRITELN (TFIL);

    END;  (*FOR M...BEGIN *)

END;  (* WRITETFIL *)

(**********************************************************************)

BEGIN
        SETUP;
        READITIN:
        CALCULATE;
        WRITETFIL;
END.
```

APPENDIX D

FILES

APPENDIX D1

FILE CONVENTIONS

FILE CONVENTIONS

The following are the file contents and filename conventions used for the experiment:

1. RAW01 thru RAW54

Raw data files, transferred directly from Hewlett Packard HP9345 into Apple IIe; RAW01 is for first "run parameter code", RAW02 for second "run parameter code", etc. The contents are explained under "SRAWxx" files.

2. TRAW01 thru TRAW54

RAWxx data files, after transforming them into text files for data manipulation and for ease of transfer between computer systems (APPLE IIe to CYBER). The contents are explained under "SRAWxx" files.

3. SRAW01 thru SRAW54

TRAW data files, after the following transformations:

a. The Run-sequence-number was added to the beginning of each file to indicate the order of the trial,

b. Commas and colons used as separators in the RAWxx and TRAWxx files were transformed into spaces, and

c. Ordering of the files was changed, so that SRAW01 corresponds to Run-Sequence-number 1 (e.g. TRAW01 was for run-parameter 1, which was the eighth trial run; therefore SRAW08 contains the same data as TRAW01. Changes in the file numbering scheme were necessitated in order not to exceed USAF noise exposure limitations.).

The first number of each record is four (4) digits; the first two digits indicate the *run parameter code* (leading zero is not printed), the last two indicate the record number.

Each of the files contain the following information:

Record 00:

Run sequence number [01 thru 54]
Date of run [YY:MM:DD (Year:Month:Date)]
Time run started [HH:MI:SS (Hour:Minute:Second)]
Run parameter code [01 thru 54]
Voice type [M (male), F (female), N (machine)]
Background noise level [105, 115] in db
Signal-to-Noise ratio over headset [0, 5, 10] in db
Precursor type [T (tone), V (voice), R (repeated warning)]

Records 01-02:

Warning stimulus order [01 thru 32 (nonsequential, in the order presented)]

The following five-record sets are repeated for each of the ten subjects:

First Record:

Subject number [01 thru 10]
Number of total tracking (primary) task stimuli
Number of correct responses to tracking (primary) task
Number of baseline tracking (primary) task stimuli
Number of baseline correct responses to tracking (primary) task

Second thru Fifth Records:

Thirty-two sets of "Response/Time" to the warning stimuli, indicating:

a. Responses to warning stimuli [01 thru 32 (in the order received; 99 indicates *no* reponse in the time allotted; correct responses should match records 01-02)], and

b. Response time [in seconds] for the preceeding warning.

Records 03-07 are for subject 1;
Records 08-12 are for subject 2;
Records 13-17 are for subject 3;
etc., thru
Records 48-52 are for subject 10.

4. SRAWTOT

Files SRAW01 thru SRAW54 combined into 1 giant datafile.

5. C101 thru C154

Conversion 1 of SRAW01 thru SRAW54.

Title Record:

Run Sequence Number, Run Parameter Code, Voice type, Background noise, S/N ratio, Precursor type

The following four-record sets are repeated for each of the ten subjects:

First Record:

Subject number
Response-Flags to warning stimuli [1 (correct), 0 (incorrect), 8 (No response in allotted time)]

Second thru Fourth Records (first number on each record is subject number):

Response times for each of the above warning stimuli

Records 01-04 are for subject 1;
Records 05-08 are for subject 2;
etc., thru
Records 37-40 are for subject 10.

Records 41 thru 50 (one record per subject):

Run sequence number
Run parameter code
Voice type
Background engine noise
S/N ratio over headset
Precursor type
Subject number

Baseline primary task performance accuracy (percent correct reponses during baseline period)

Primary task performance accuracy (percent correct responses, excluding reponses during baseline period)

Primary performance reduction (baseline minus primary)

Primary percentage of peak [baseline] performance (primary over baseline)

Secondary (warning) task number correct reponses

Secondary task number of "no-responses within allotted time"

Secondary task performance (percent correct responses)

Secondary task average response time for correct responses

Record 51:

(Group performance measures):

Runs sequence number

Run parameters code

Baseline primary task performance accuracy

Primary task performance accuracy

Primary task performance reduction

Primary task percentage reduction

Secondary task mean number correct

Secondary task mean number of "no-responses within allotted time"

Secondary task overall performance accuracy

Secondary task overall reaction speed (correct reponses only)

6. C1FIL

Files C101 thru C154 combined into 1 giant datafile, including group performance measures.

7. SUBFIL

Subject summary measures, as described in records 41-50 for each "C1xx" file: one record per subject, for each run. Used as data base for some regression runs and the MANOVA.

8. GPFIL

Group performance measures only, as listed in Record 51 for each "C1xx" file; one record for each run.

9. SDAT

Data file for use with some regressions, the ANOVA program, the within-runs t-test, and other programs. The data file is organized in order of the sequence of runs; within each run, by subject number; within each subject, by the sequence in which the stimuli were given.
Each line (record) contains the following information:

Run sequence number [1-54]

Voice type [M, F, N]

Background engine noise level [105, 115] in db

Signal-to-noise ratio over headset [0, 5, 10] in db

Precursor type [T, W, R]
Subject number [1-10]
Stimulus sequence number [1-32, in order]
Stimulus [1-32, corresponds to stimulus actually called for]
Response to stimulus [1-32, or 99 for no response]
Stimulus response code [1, 0, 8]
Response time for stimulus, in seconds
Baselin primary task tracking accuracy
Primary task individually-normalized accuracy during "stimulus" conditions.

APPENDIX D2

SUBJECT PERFORMANCE FILE

(SUBFIL)

RN	RP	V	BKD	SN	PC	SUB	BLINE	PRIM	ACLOS	NORML	CR	NR	ACCY	TIME
1	5	N	115	0	W	1	0.942	0.912	0.030	0.968	29	1	0.906	3.125
1	5	N	115	0	W	2	0.912	0.852	0.060	0.934	26	3	0.812	3.332
1	5	N	115	0	W	3	0.826	0.771	0.055	0.933	11	4	0.344	3.057
1	5	N	115	0	W	4	0.900	0.877	0.023	0.974	25	2	0.781	2.408
1	5	N	115	0	W	5	0.758	0.614	0.145	0.809	26	1	0.812	2.969
1	5	N	115	0	W	6	0.862	0.862	0.001	0.999	29	2	0.906	2.727
1	5	N	115	0	W	7	0.966	0.926	0.040	0.958	28	0	0.875	2.606
1	5	N	115	0	W	8	0.800	0.765	0.035	0.956	27	2	0.844	2.847
1	5	N	115	0	W	9	0.731	0.614	0.116	0.841	27	0	0.844	2.498
1	5	N	115	0	W	10	0.948	0.911	0.037	0.960	29	1	0.906	2.093
2	6	M	115	10	T	1	0.920	0.912	0.009	0.990	32	0	1.000	2.902
2	6	M	115	10	T	2	0.817	0.813	0.004	0.995	29	3	0.906	3.202
2	6	M	115	10	T	3	0.738	0.612	0.125	0.830	25	0	0.781	2.827
2	6	M	115	10	T	4	0.893	0.814	0.079	0.912	30	1	0.937	2.126
2	6	M	115	10	T	5	0.809	0.761	0.049	0.940	32	0	1.000	2.782
2	6	M	115	10	T	6	0.909	0.864	0.045	0.951	32	0	1.000	2.540
2	6	M	115	10	T	7	0.958	0.934	0.024	0.975	32	0	1.000	2.395
2	6	M	115	10	T	8	0.767	0.692	0.076	0.901	31	0	0.969	2.701
2	6	M	115	10	T	9	0.805	0.718	0.087	0.892	30	0	0.937	2.290
2	6	M	115	10	T	10	0.938	0.925	0.014	0.985	32	0	1.000	1.889
3	13	M	105	10	T	1	0.920	0.909	0.011	0.988	32	0	1.000	2.786
3	13	M	105	10	T	2	0.831	0.763	0.068	0.919	32	0	1.000	3.146
3	13	M	105	10	T	3	0.771	0.747	0.024	0.968	23	0	0.719	2.748
3	13	M	105	10	T	4	0.938	0.903	0.035	0.963	30	0	0.937	2.201
3	13	M	105	10	T	5	0.895	0.864	0.030	0.966	29	1	0.906	3.030
3	13	M	105	10	T	6	0.917	0.856	0.060	0.934	30	0	0.937	2.493
3	13	M	105	10	T	7	0.928	0.924	0.004	0.996	30	0	0.937	2.403
3	13	M	105	10	T	8	0.817	0.766	0.051	0.938	31	0	0.969	2.532
3	13	M	105	10	T	9	0.674	0.696	-0.022	1.032	29	0	0.906	2.256
3	13	M	105	10	T	10	0.907	0.905	0.002	0.998	32	0	1.000	1.821
4	10	F	115	10	R	1	0.952	0.937	0.015	0.984	32	0	1.000	2.813
4	10	F	115	10	R	2	0.902	0.843	0.059	0.934	32	0	1.000	3.254
4	10	F	115	10	R	3	0.884	0.792	0.092	0.896	23	0	0.719	2.635
4	10	F	115	10	R	4	0.924	0.876	0.048	0.948	32	0	1.000	2.040
4	10	F	115	10	R	5	0.795	0.783	0.011	0.986	32	0	1.000	2.835
4	10	F	115	10	R	6	0.898	0.844	0.055	0.939	32	0	1.000	2.226
4	10	F	115	10	R	7	0.926	0.937	-0.010	1.011	28	1	0.875	2.887
4	10	F	115	10	R	8	0.813	0.753	0.060	0.927	31	0	0.969	2.475
4	10	F	115	10	R	9	0.635	0.626	0.010	0.984	29	0	0.906	2.115
4	10	F	115	10	R	10	0.962	0.908	0.054	0.944	31	0	0.969	1.779
5	9	M	115	5	W	1	0.924	0.930	-0.005	1.006	32	0	1.000	3.095
5	9	M	115	5	W	2	0.851	0.803	0.048	0.943	30	1	0.937	3.448
5	9	M	115	5	W	3	0.746	0.591	0.155	0.793	26	0	0.812	2.970
5	9	M	115	5	W	4	0.903	0.840	0.063	0.930	31	1	0.969	2.349
5	9	M	115	5	W	5	0.879	0.810	0.069	0.922	29	2	0.906	3.158
5	9	M	115	5	W	6	0.851	0.839	0.012	0.986	29	1	0.906	2.620
5	9	M	115	5	W	7	0.942	0.928	0.014	0.985	29	0	0.906	2.872
5	9	M	115	5	W	8	0.809	0.793	0.016	0.980	29	1	0.906	2.783
5	9	M	115	5	W	9	0.712	0.625	0.086	0.879	29	0	0.906	2.736
5	9	M	115	5	W	10	0.952	0.916	0.036	0.962	30	0	0.937	2.105

RN	RP	V	BKD	SN	PC	SUB	BLINE	PRIM	ACLOS	NORML	CR	NR	ACCY	TIME
6	11	N	105	0	T	1	0.928	0.906	0.022	0.976	29	0	0.706	3.337
6	11	N	105	0	T	2	0.839	0.784	0.055	0.934	25	2	0.781	3.305
6	11	N	105	0	T	3	0.724	0.528	0.195	0.730	26	1	0.812	2.943
6	11	N	105	0	T	4	0.877	0.824	0.052	0.940	28	1	0.875	2.231
6	11	N	105	0	T	5	0.863	0.842	0.021	0.975	28	1	0.875	2.725
6	11	N	105	0	T	6	0.980	0.895	0.085	0.913	28	2	0.875	2.483
6	11	N	105	0	T	7	0.946	0.902	0.045	0.953	31	0	0.969	2.681
6	11	N	105	0	T	8	0.809	0.715	0.095	0.883	28	0	0.875	2.618
6	11	N	105	0	T	9	0.771	0.604	0.167	0.783	28	0	0.875	2.563
6	11	N	105	0	T	10	0.964	0.910	0.054	0.944	30	0	0.937	2.041
7	14	F	105	10	W	1	0.903	0.899	0.003	0.996	32	0	1.000	3.090
7	14	F	105	10	W	2	0.811	0.802	0.009	0.989	31	0	0.969	3.562
7	14	F	105	10	W	3	0.471	0.545	-0.074	1.157	24	0	0.750	2.808
7	14	F	105	10	W	4	0.905	0.833	0.072	0.921	31	0	0.969	2.276
7	14	F	105	10	W	5	0.781	0.830	-0.049	1.063	32	0	1.000	3.024
7	14	F	105	10	W	6	0.934	0.876	0.058	0.938	32	0	1.000	2.660
7	14	F	105	10	W	7	0.932	0.920	0.013	0.987	31	1	0.969	2.760
7	14	F	105	10	W	8	0.694	0.747	-0.053	1.076	30	1	0.937	2.865
7	14	F	105	10	W	9	0.726	0.727	-0.001	1.002	32	0	1.000	2.747
7	14	F	105	10	W	10	0.922	0.901	0.022	0.976	32	0	1.000	2.100
8	1	M	115	0	R	1	0.928	0.915	0.013	0.986	30	0	0.937	3.108
8	1	M	115	0	R	2	0.899	0.862	0.037	0.959	32	0	1.000	3.020
8	1	M	115	0	R	3	0.829	0.845	-0.016	1.019	23	0	0.719	3.252
8	1	M	115	0	R	4	0.831	0.841	-0.010	1.012	30	0	0.937	2.357
8	1	M	115	0	R	5	0.885	0.842	0.043	0.951	32	0	1.000	2.719
8	1	M	115	0	R	6	0.952	0.928	0.025	0.974	32	0	1.000	2.440
8	1	M	115	0	R	7	0.982	0.952	0.030	0.969	31	0	0.969	2.909
8	1	M	115	0	R	8	0.473	0.658	-0.185	1.392	30	0	0.937	2.746
8	1	M	115	0	R	9	0.767	0.712	0.055	0.928	32	0	1.000	2.647
8	1	M	115	0	R	10	0.940	0.900	0.040	0.958	32	0	1.000	1.974
9	2	N	115	5	T	1	0.916	0.905	0.011	0.988	30	0	0.937	3.113
9	2	N	115	5	T	2	0.870	0.841	0.029	0.967	26	1	0.812	2.966
9	2	N	115	5	T	3	0.780	0.702	0.078	0.900	17	1	0.531	3.197
9	2	N	115	5	T	4	0.942	0.905	0.037	0.960	27	3	0.844	2.398
9	2	N	115	5	T	5	0.898	0.855	0.043	0.952	29	0	0.906	2.885
9	2	N	115	5	T	6	0.928	0.895	0.033	0.964	28	2	0.875	2.543
9	2	N	115	5	T	7	0.968	0.947	0.021	0.978	32	0	1.000	2.970
9	2	N	115	5	T	8	0.683	0.695	-0.012	1.018	28	0	0.875	3.071
9	2	N	115	5	T	9	0.804	0.748	0.057	0.929	29	0	0.906	2.698
9	2	N	115	5	T	10	0.932	0.900	0.032	0.965	29	0	0.906	1.922
10	3	N	105	0	W	1	0.936	0.906	0.030	0.968	31	1	0.969	3.182
10	3	N	105	0	W	2	0.900	0.846	0.055	0.939	28	2	0.875	3.287
10	3	N	105	0	W	3	0.837	0.614	0.222	0.734	31	0	0.969	3.230
10	3	N	105	0	W	4	0.920	0.810	0.111	0.880	29	1	0.906	2.509
10	3	N	105	0	W	5	0.880	0.849	0.031	0.964	30	1	0.937	3.034
10	3	N	105	0	W	6	0.906	0.854	0.053	0.942	29	2	0.906	2.696
10	3	N	105	0	W	7	0.972	0.937	0.035	0.964	32	0	1.000	3.067
10	3	N	105	0	W	8	0.801	0.616	0.185	0.769	27	2	0.844	3.003
10	3	N	105	0	W	9	0.865	0.710	0.155	0.821	28	0	0.875	2.719
10	3	N	105	0	W	10	0.926	0.903	0.023	0.975	31	0	0.969	2.044

RN	RP	V	BKD	SN	PC	SUB	BLINE	PRIM	ACLOS	NORML	CR	NR	ACCY	TIME
11	15	F	105	10	R	1	0.908	0.916	-0.008	1.009	31	0	0.969	3.293
11	15	F	105	10	R	2	0.830	0.802	0.028	0.966	31	0	0.969	3.550
11	15	F	105	10	R	3	0.758	0.748	0.010	0.986	27	0	0.844	2.843
11	15	F	105	10	R	4	0.872	0.840	0.033	0.963	32	0	1.000	2.211
11	15	F	105	10	R	5	0.858	0.838	0.021	0.976	32	0	1.000	2.882
11	15	F	105	10	R	6	0.794	0.820	-0.025	1.032	32	0	1.000	2.259
11	15	F	105	10	R	7	0.972	0.943	0.029	0.970	32	0	1.000	2.703
11	15	F	105	10	R	8	0.591	0.612	-0.021	1.035	32	0	1.000	2.737
11	15	F	105	10	R	9	0.842	0.823	0.019	0.977	31	0	0.969	2.602
11	15	F	105	10	R	10	0.908	0.894	0.014	0.984	32	0	1.000	1.845
12	4	N	115	0	T	1	0.954	0.953	0.001	0.999	29	0	0.906	3.240
12	4	N	115	0	T	2	0.915	0.875	0.039	0.957	28	1	0.875	3.149
12	4	N	115	0	T	3	0.920	0.906	0.015	0.984	26	0	0.812	3.508
12	4	N	115	0	T	4	0.952	0.930	0.023	0.976	30	0	0.937	2.375
12	4	N	115	0	T	5	0.857	0.817	0.040	0.954	28	1	0.875	2.910
12	4	N	115	0	T	6	0.873	0.884	-0.012	1.013	29	2	0.906	2.426
12	4	N	115	0	T	7	0.978	0.954	0.024	0.975	31	0	0.969	3.072
12	4	N	115	0	T	8	0.793	0.681	0.112	0.859	30	1	0.937	3.020
12	4	N	115	0	T	9	0.823	0.775	0.048	0.942	31	1	0.969	2.634
12	4	N	115	0	T	10	0.930	0.921	0.009	0.990	29	3	0.906	1.916
13	7	M	115	5	T	1	0.944	0.928	0.017	0.982	30	0	0.937	3.035
13	7	M	115	5	T	2	0.813	0.829	-0.016	1.019	28	3	0.875	3.123
13	7	M	115	5	T	3	0.880	0.886	-0.005	1.006	26	1	0.812	2.942
13	7	M	115	5	T	4	0.938	0.910	0.029	0.970	30	0	0.937	2.394
13	7	M	115	5	T	5	0.779	0.807	-0.028	1.036	32	0	1.000	3.085
13	7	M	115	5	T	6	0.807	0.822	-0.015	1.018	31	0	0.969	2.514
13	7	M	115	5	T	7	0.974	0.957	0.018	0.982	31	0	0.969	3.266
13	7	M	115	5	T	8	0.663	0.688	-0.025	1.037	26	2	0.812	3.452
13	7	M	115	5	T	9	0.839	0.814	0.025	0.971	32	0	1.000	2.924
13	7	M	115	5	T	10	0.928	0.927	0.001	0.999	32	0	1.000	1.933
14	16	F	105	5	R	1	0.917	0.911	0.006	0.993	29	0	0.906	3.086
14	16	F	105	5	R	2	0.921	0.842	0.079	0.915	32	0	1.000	3.505
14	16	F	105	5	R	3	0.597	0.808	-0.210	1.352	28	0	0.875	2.999
14	16	F	105	5	R	4	0.897	0.902	-0.005	1.006	31	1	0.969	2.270
14	16	F	105	5	R	5	0.877	0.856	0.021	0.976	32	0	1.000	3.011
14	16	F	105	5	R	6	0.917	0.882	0.034	0.963	31	0	0.969	2.367
14	16	F	105	5	R	7	0.962	0.953	0.010	0.990	29	1	0.906	3.326
14	16	F	105	5	R	8	0.784	0.692	0.092	0.883	32	0	1.000	3.441
14	16	F	105	5	R	9	0.760	0.735	0.025	0.968	31	0	0.969	2.602
14	16	F	105	5	R	10	0.931	0.903	0.028	0.970	31	1	0.969	1.899
15	17	F	105	0	T	1	0.940	0.915	0.025	0.973	32	0	1.000	3.186
15	17	F	105	0	T	2	0.883	0.846	0.037	0.958	28	4	0.875	2.745
15	17	F	105	0	T	3	0.809	0.828	-0.019	1.023	26	1	0.812	3.192
15	17	F	105	0	T	4	0.970	0.936	0.034	0.964	31	0	0.969	2.216
15	17	F	105	0	T	5	0.891	0.861	0.029	0.967	32	0	1.000	2.844
15	17	F	105	0	T	6	0.859	0.798	0.061	0.929	31	0	0.969	2.412
15	17	F	105	0	T	7	0.970	0.950	0.020	0.979	32	0	1.000	3.038
15	17	F	105	0	T	8	0.837	0.800	0.037	0.956	31	1	0.969	2.769
15	17	F	105	0	T	9	0.851	0.783	0.068	0.920	31	0	0.969	2.546
15	17	F	105	0	T	10	0.823	0.891	-0.068	1.083	32	0	1.000	1.798

RN	RP	V	BKD	SN	PC	SUB	BLINE	PRIM	ACLOS	NORML	CR	NR	ACCY	TIME
==	==	=	===	==	==	===	=====	=====	=====	=====	==	==	=====	=====
16	8	M	115	0	W	1	0.956	0.947	0.009	0.990	32	0	1.000	3.212
16	8	M	115	0	W	2	0.911	0.850	0.061	0.933	32	0	1.000	3.198
16	8	M	115	0	W	3	0.960	0.884	0.076	0.921	27	0	0.844	3.342
16	8	M	115	0	W	4	0.954	0.894	0.060	0.937	30	1	0.937	2.411
16	8	M	115	0	W	5	0.918	0.875	0.044	0.952	30	0	0.937	2.806
16	8	M	115	0	W	6	0.928	0.871	0.057	0.938	29	0	0.906	2.772
16	8	M	115	0	W	7	0.972	0.946	0.026	0.974	30	0	0.937	3.650
16	8	M	115	0	W	8	0.889	0.688	0.201	0.774	29	2	0.906	3.241
16	8	M	115	0	W	9	0.795	0.724	0.071	0.910	32	0	1.000	2.949
16	8	M	115	0	W	10	0.901	0.809	0.091	0.898	29	0	0.906	2.194
17	12	F	115	5	T	1	0.965	0.930	0.035	0.964	30	0	0.937	3.049
17	12	F	115	5	T	2	0.860	0.825	0.035	0.959	27	3	0.844	3.187
17	12	F	115	5	T	3	0.899	0.838	0.061	0.932	26	2	0.812	3.440
17	12	F	115	5	T	4	0.920	0.905	0.015	0.984	29	0	0.906	2.179
17	12	F	115	5	T	5	0.922	0.870	0.052	0.943	29	0	0.906	2.565
17	12	F	115	5	T	6	0.940	0.801	0.139	0.852	31	0	0.969	2.595
17	12	F	115	5	T	7	0.961	0.940	0.021	0.978	32	0	1.000	3.221
17	12	F	115	5	T	8	0.713	0.571	0.142	0.801	26	3	0.812	2.851
17	12	F	115	5	T	9	0.903	0.811	0.092	0.898	32	0	1.000	2.570
17	12	F	115	5	T	10	0.965	0.894	0.071	0.927	32	0	1.000	1.937
18	18	M	105	0	R	1	0.966	0.938	0.028	0.971	31	0	0.969	3.204
18	18	M	105	0	R	2	0.861	0.832	0.029	0.967	31	1	0.969	3.760
18	18	M	105	0	R	3	0.883	0.641	0.242	0.726	32	0	1.000	3.181
18	18	M	105	0	R	4	0.922	0.899	0.023	0.975	31	1	0.969	2.114
18	18	M	105	0	R	5	0.885	0.862	0.022	0.975	31	0	0.969	3.228
18	18	M	105	0	R	6	0.950	0.881	0.069	0.927	31	0	0.969	2.762
18	18	M	105	0	R	7	0.968	0.951	0.017	0.983	32	0	1.000	3.375
18	18	M	105	0	R	8	0.855	0.792	0.063	0.926	29	2	0.906	3.340
18	18	M	105	0	R	9	0.873	0.769	0.104	0.881	32	0	1.000	2.879
18	18	M	105	0	R	10	0.944	0.890	0.054	0.942	32	0	1.000	1.782
19	19	N	105	0	R	1	0.954	0.930	0.024	0.974	32	0	1.000	3.298
19	19	N	105	0	R	2	0.905	0.846	0.059	0.935	31	1	0.969	3.484
19	19	N	105	0	R	3	0.791	0.778	0.013	0.984	29	1	0.906	3.247
19	19	N	105	0	R	4	0.946	0.882	0.065	0.932	32	0	1.000	2.111
19	19	N	105	0	R	5	0.879	0.846	0.033	0.962	31	0	0.969	3.435
19	19	N	105	0	R	6	0.913	0.876	0.036	0.960	32	0	1.000	2.981
19	19	N	105	0	R	7	0.960	0.956	0.004	0.996	32	0	1.000	3.443
19	19	N	105	0	R	8	0.841	0.788	0.053	0.937	29	3	0.906	3.745
19	19	N	105	0	R	9	0.837	0.777	0.060	0.929	32	0	1.000	2.788
19	19	N	105	0	R	10	0.932	0.914	0.019	0.980	32	0	1.000	1.877
20	20	F	115	0	W	1	0.948	0.949	-0.001	1.001	28	0	0.875	3.229
20	20	F	115	0	W	2	0.960	0.856	0.104	0.892	28	0	0.875	3.582
20	20	F	115	0	W	3	0.887	0.851	0.035	0.960	24	4	0.750	3.708
20	20	F	115	0	W	4	0.950	0.898	0.052	0.945	26	1	0.812	2.477
20	20	F	115	0	W	5	0.913	0.881	0.032	0.965	27	1	0.844	2.750
20	20	F	115	0	W	6	0.966	0.920	0.047	0.952	28	1	0.875	2.917
20	20	F	115	0	W	7	0.962	0.927	0.035	0.963	27	0	0.844	3.545
20	20	F	115	0	W	8	0.924	0.824	0.100	0.891	24	1	0.750	3.066
20	20	F	115	0	W	9	0.871	0.755	0.116	0.867	27	0	0.844	2.840
20	20	F	115	0	W	10	0.976	0.918	0.058	0.940	28	0	0.875	2.124

RN	RP	V	BKD	SN	PC	SUB	BLINE	PRIM	ACLOS	NORML	CR	NR	ACCY	TIME
==	==	=	===	==	==	===	=====	=====	=====	=====	==	==	=====	=====
21	21	N	105	10	R	1	0.962	0.941	0.021	0.978	30	0	0.937	3.271
21	21	N	105	10	R	2	0.883	0.855	0.028	0.968	32	0	1.000	3.756
21	21	N	105	10	R	3	0.823	0.737	0.086	0.895	30	1	0.937	3.636
21	21	N	105	10	R	4	0.922	0.896	0.027	0.971	31	0	0.969	2.389
21	21	N	105	10	R	5	0.883	0.847	0.035	0.960	32	0	1.000	3.158
21	21	N	105	10	R	6	0.887	0.838	0.048	0.945	32	0	1.000	3.190
21	21	N	105	10	R	7	0.966	0.919	0.048	0.951	30	1	0.937	3.900
21	21	N	105	10	R	8	0.932	0.858	0.075	0.920	29	2	0.906	3.379
21	21	N	105	10	R	9	0.922	0.814	0.108	0.883	31	0	0.969	2.941
21	21	N	105	10	R	10	0.956	0.941	0.015	0.984	31	1	0.969	1.858
22	22	F	105	0	W	1	0.952	0.942	0.010	0.989	32	0	1.000	3.423
22	22	F	105	0	W	2	0.871	0.845	0.026	0.970	28	2	0.875	3.464
22	22	F	105	0	W	3	0.821	0.734	0.086	0.895	28	0	0.875	3.588
22	22	F	105	0	W	4	0.950	0.895	0.056	0.942	29	0	0.906	2.464
22	22	F	105	0	W	5	0.875	0.839	0.036	0.959	32	0	1.000	3.011
22	22	F	105	0	W	6	0.924	0.843	0.081	0.912	29	0	0.906	2.874
22	22	F	105	0	W	7	0.976	0.928	0.048	0.951	30	0	0.937	2.896
22	22	F	105	0	W	8	0.932	0.836	0.096	0.897	30	2	0.937	3.312
22	22	F	105	0	W	9	0.888	0.780	0.109	0.878	31	0	0.969	2.708
22	22	F	105	0	W	10	0.964	0.922	0.042	0.956	31	0	0.969	2.070
23	24	F	115	5	W	1	0.948	0.945	0.003	0.997	30	0	0.937	3.272
23	24	F	115	5	W	2	0.875	0.860	0.015	0.983	29	1	0.906	3.382
23	24	F	115	5	W	3	0.338	0.582	-0.244	1.722	26	1	0.812	3.411
23	24	F	115	5	W	4	0.915	0.889	0.025	0.973	27	2	0.844	2.231
23	24	F	115	5	W	5	0.861	0.866	-0.005	1.006	30	1	0.937	2.989
23	24	F	115	5	W	6	0.857	0.877	-0.020	1.023	29	1	0.906	2.660
23	24	F	115	5	W	7	0.978	0.933	0.045	0.954	30	0	0.937	2.763
23	24	F	115	5	W	8	0.833	0.817	0.016	0.981	29	2	0.906	3.307
23	24	F	115	5	W	9	0.853	0.833	0.020	0.977	29	0	0.906	2.646
23	24	F	115	5	W	10	0.905	0.917	-0.013	1.014	28	0	0.875	2.074
24	23	M	105	5	T	1	0.976	0.940	0.036	0.963	31	0	0.969	3.167
24	23	M	105	5	T	2	0.924	0.871	0.053	0.942	31	0	0.969	3.110
24	23	M	105	5	T	3	0.934	0.902	0.032	0.966	28	2	0.875	3.353
24	23	M	105	5	T	4	0.950	0.930	0.020	0.979	32	0	1.000	2.411
24	23	M	105	5	T	5	0.819	0.831	-0.012	1.015	31	0	0.969	2.604
24	23	M	105	5	T	6	0.884	0.865	0.020	0.978	32	0	1.000	2.535
24	23	M	105	5	T	7	0.962	0.933	0.029	0.970	31	0	0.969	2.691
24	23	M	105	5	T	8	0.821	0.812	0.009	0.990	29	1	0.906	3.357
24	23	M	105	5	T	9	0.793	0.751	0.041	0.948	31	0	0.969	2.523
24	23	M	105	5	T	10	0.966	0.924	0.042	0.957	31	0	0.969	1.968
25	25	M	115	10	R	1	0.942	0.927	0.015	0.985	31	0	0.969	3.430
25	25	M	115	10	R	2	0.899	0.849	0.051	0.943	32	0	1.000	3.349
25	25	M	115	10	R	3	0.892	0.856	0.036	0.960	31	0	0.969	3.445
25	25	M	115	10	R	4	0.946	0.909	0.037	0.961	32	0	1.000	2.313
25	25	M	115	10	R	5	0.919	0.824	0.095	0.897	32	0	1.000	3.023
25	25	M	115	10	R	6	0.845	0.868	-0.023	1.027	32	0	1.000	3.004
25	25	M	115	10	R	7	0.969	0.938	0.032	0.967	32	0	1.000	3.137
25	25	M	115	10	R	8	0.901	0.606	0.295	0.672	31	0	0.969	3.724
25	25	M	115	10	R	9	0.870	0.802	0.069	0.921	32	0	1.000	2.677
25	25	M	115	10	R	10	0.971	0.918	0.053	0.945	28	1	0.875	2.016

RN	RP	V	BKD	SN	PC	SUB	BLINE	PRIM	ACLOS	NORML	CR	NR	ACCY	TIME
26	26	N	105	10	T	1	0.944	0.914	0.031	0.967	31	0	0.969	3.105
26	26	N	105	10	T	2	0.837	0.844	-0.007	1.008	31	0	0.969	2.974
26	26	N	105	10	T	3	0.855	0.752	0.103	0.880	30	0	0.937	3.348
26	26	N	105	10	T	4	0.930	0.910	0.021	0.978	29	0	0.906	2.350
26	26	N	105	10	T	5	0.883	0.773	0.109	0.876	30	0	0.937	2.390
26	26	N	105	10	T	6	0.843	0.857	-0.014	1.017	30	0	0.937	2.858
26	26	N	105	10	T	7	0.954	0.951	0.003	0.997	32	0	1.000	2.644
26	26	N	105	10	T	8	0.773	0.650	0.123	0.840	27	4	0.844	3.163
26	26	N	105	10	T	9	0.865	0.761	0.104	0.880	30	1	0.937	2.424
26	26	N	105	10	T	10	0.948	0.926	0.022	0.977	29	0	0.906	1.957
27	27	F	115	0	R	1	0.938	0.923	0.015	0.984	31	0	0.969	3.105
27	27	F	115	0	R	2	0.880	0.840	0.041	0.954	30	2	0.937	3.463
27	27	F	115	0	R	3	0.878	0.764	0.114	0.870	23	0	0.719	3.146
27	27	F	115	0	R	4	0.890	0.894	-0.003	1.004	28	0	0.875	2.155
27	27	F	115	0	R	5	0.890	0.840	0.050	0.944	31	0	0.969	2.491
27	27	F	115	0	R	6	0.952	0.867	0.086	0.910	31	0	0.969	2.550
27	27	F	115	0	R	7	0.976	0.954	0.023	0.977	30	0	0.937	2.569
27	27	F	115	0	R	8	0.803	0.641	0.162	0.798	30	0	0.937	3.156
27	27	F	115	0	R	9	0.918	0.742	0.176	0.808	31	0	0.969	2.419
27	27	F	115	0	R	10	0.958	0.914	0.044	0.954	29	0	0.906	1.941
28	28	N	115	10	T	1	0.940	0.937	0.003	0.997	31	1	0.969	3.168
28	28	N	115	10	T	2	0.932	0.912	0.020	0.978	32	0	1.000	3.059
28	28	N	115	10	T	3	0.948	0.882	0.066	0.930	28	1	0.875	3.357
28	28	N	115	10	T	4	0.964	0.924	0.040	0.958	30	0	0.937	2.133
28	28	N	115	10	T	5	0.868	0.835	0.034	0.961	30	0	0.937	2.722
28	28	N	115	10	T	6	0.978	0.874	0.104	0.894	29	1	0.906	2.767
28	28	N	115	10	T	7	0.992	0.958	0.034	0.966	31	0	0.969	2.842
28	28	N	115	10	T	8	0.918	0.874	0.044	0.952	30	0	0.937	2.647
28	28	N	115	10	T	9	0.938	0.763	0.175	0.813	31	0	0.969	2.606
28	28	N	115	10	T	10	0.946	0.892	0.055	0.942	31	0	0.969	1.942
29	29	N	115	5	R	1	0.958	0.942	0.016	0.983	32	0	1.000	3.166
29	29	N	115	5	R	2	0.891	0.890	0.000	0.999	28	3	0.875	3.680
29	29	N	115	5	R	3	0.803	0.741	0.062	0.922	32	0	1.000	3.404
29	29	N	115	5	R	4	0.952	0.908	0.044	0.954	31	0	0.969	2.283
29	29	N	115	5	R	5	0.821	0.842	-0.020	1.025	31	0	0.969	3.073
29	29	N	115	5	R	6	0.922	0.845	0.077	0.916	29	0	0.906	2.767
29	29	N	115	5	R	7	0.982	0.955	0.027	0.973	32	0	1.000	3.201
29	29	N	115	5	R	8	0.952	0.864	0.089	0.907	32	0	1.000	3.178
29	29	N	115	5	R	9	0.835	0.750	0.085	0.898	30	0	0.937	2.508
29	29	N	115	5	R	10	0.924	0.924	0.000	1.000	31	0	0.969	1.816
30	32	M	105	10	R	1	0.950	0.938	0.012	0.987	32	0	1.000	2.779
30	32	M	105	10	R	2	0.934	0.871	0.063	0.933	32	0	1.000	3.594
30	32	M	105	10	R	3	0.564	0.491	0.073	0.871	30	1	0.937	3.132
30	32	M	105	10	R	4	0.924	0.903	0.022	0.977	32	0	1.000	2.201
30	32	M	105	10	R	5	0.902	0.834	0.069	0.924	30	1	0.937	3.194
30	32	M	105	10	R	6	0.960	0.877	0.083	0.914	32	0	1.000	3.062
30	32	M	105	10	R	7	0.960	0.930	0.030	0.969	32	0	1.000	3.343
30	32	M	105	10	R	8	0.936	0.858	0.078	0.917	31	0	0.969	3.475
30	32	M	105	10	R	9	0.835	0.734	0.101	0.879	32	0	1.000	2.601
30	32	M	105	10	R	10	0.962	0.922	0.040	0.958	32	0	1.000	1.833

RN	RP	V	BKD	SN	PC	SUB	BLINE	PRIM	ACLOS	NORML	CR	NR	ACCY	TIME
==	==	=	===	==	==	===	=====	=====	=====	=====	==	==	=====	=====
31	30	F	115	0	T	1	0.942	0.958	-0.016	1.017	31	0	0.969	2.914
31	30	F	115	0	T	2	0.920	0.888	0.032	0.965	32	0	1.000	2.898
31	30	F	115	0	T	3	0.910	0.912	-0.001	1.001	26	0	0.812	3.420
31	30	F	115	0	T	4	0.942	0.931	0.011	0.988	30	0	0.937	2.105
31	30	F	115	0	T	5	0.825	0.793	0.032	0.961	30	0	0.937	2.547
31	30	F	115	0	T	6	0.928	0.840	0.088	0.905	29	1	0.906	2.942
31	30	F	115	0	T	7	0.998	0.970	0.028	0.972	32	0	1.000	2.941
31	30	F	115	0	T	8	0.920	0.851	0.070	0.924	27	5	0.844	2.933
31	30	F	115	0	T	9	0.789	0.734	0.055	0.931	30	0	0.937	2.544
31	30	F	115	0	T	10	0.936	0.925	0.011	0.988	30	0	0.937	1.961
32	31	M	115	5	R	1	0.952	0.931	0.021	0.978	32	0	1.000	3.074
32	31	M	115	5	R	2	0.803	0.832	-0.030	1.037	32	0	1.000	3.467
32	31	M	115	5	R	3	0.880	0.829	0.052	0.941	29	1	0.906	3.563
32	31	M	115	5	R	4	0.956	0.930	0.026	0.973	32	0	1.000	2.196
32	31	M	115	5	R	5	0.920	0.874	0.047	0.949	32	0	1.000	2.808
32	31	M	115	5	R	6	0.902	0.871	0.031	0.965	32	0	1.000	3.240
32	31	M	115	5	R	7	0.974	0.967	0.007	0.993	32	0	1.000	3.304
32	31	M	115	5	R	8	0.888	0.856	0.033	0.963	28	4	0.875	3.111
32	31	M	115	5	R	9	0.697	0.744	-0.047	1.067	32	0	1.000	2.571
32	31	M	115	5	R	10	0.952	0.920	0.032	0.966	32	0	1.000	2.114
33	35	M	105	10	W	1	0.942	0.944	-0.002	1.002	32	0	1.000	3.321
33	35	M	105	10	W	2	0.893	0.815	0.077	0.913	30	2	0.937	3.469
33	35	M	105	10	W	3	0.475	0.546	-0.071	1.149	28	0	0.875	3.509
33	35	M	105	10	W	4	0.948	0.910	0.039	0.959	32	0	1.000	2.377
33	35	M	105	10	W	5	0.950	0.836	0.115	0.879	31	0	0.969	2.767
33	35	M	105	10	W	6	0.893	0.841	0.052	0.942	30	0	0.937	3.130
33	35	M	105	10	W	7	0.946	0.943	0.003	0.997	32	0	1.000	3.136
33	35	M	105	10	W	8	0.950	0.894	0.056	0.941	25	5	0.781	3.182
33	35	M	105	10	W	9	0.740	0.653	0.087	0.882	32	0	1.000	2.667
33	35	M	105	10	W	10	0.950	0.924	0.027	0.972	31	0	0.969	2.310
34	37	F	105	10	T	1	0.954	0.931	0.024	0.975	32	0	1.000	2.937
34	37	F	105	10	T	2	0.863	0.851	0.012	0.986	32	0	1.000	3.229
34	37	F	105	10	T	3	0.476	0.424	0.052	0.890	25	2	0.781	3.178
34	37	F	105	10	T	4	0.937	0.920	0.016	0.983	32	0	1.000	2.017
34	37	F	105	10	T	5	0.889	0.793	0.096	0.892	31	1	0.969	2.378
34	37	F	105	10	T	6	0.925	0.877	0.048	0.948	32	0	1.000	2.822
34	37	F	105	10	T	7	0.974	0.943	0.031	0.968	32	0	1.000	2.989
34	37	F	105	10	T	8	0.923	0.884	0.039	0.958	26	4	0.812	2.876
34	37	F	105	10	T	9	0.810	0.735	0.075	0.908	29	0	0.906	2.420
34	37	F	105	10	T	10	0.962	0.899	0.063	0.934	32	0	1.000	1.940
35	33	N	115	5	W	1	0.962	0.945	0.017	0.982	32	0	1.000	3.230
35	33	N	115	5	W	2	0.924	0.884	0.040	0.957	29	1	0.906	3.440
35	33	N	115	5	W	3	0.907	0.898	0.009	0.991	25	1	0.781	3.511
35	33	N	115	5	W	4	0.950	0.929	0.022	0.977	32	0	1.000	2.497
35	33	N	115	5	W	5	0.920	0.876	0.044	0.952	31	0	0.969	3.093
35	33	N	115	5	W	6	0.932	0.914	0.018	0.980	30	0	0.937	2.973
35	33	N	115	5	W	7	0.986	0.973	0.013	0.987	31	0	0.969	3.227
35	33	N	115	5	W	8	0.917	0.895	0.022	0.976	24	4	0.750	2.938
35	33	N	115	5	W	9	0.875	0.810	0.065	0.926	30	0	0.937	2.654
35	33	N	115	5	W	10	0.948	0.925	0.023	0.975	30	1	0.937	2.146

RN	RP	V	BKD	SN	PC	SUB	BLINE	PRIM .	ACLOS	NORML	CR	NR	ACCY	TIME
36	34	N	115	10	R	1	0.926	0.928	-0.001	1.002	31	1	0.969	3.310
36	34	N	115	10	R	2	0.922	0.893	0.029	0.968	31	1	0.969	3.815
36	34	N	115	10	R	3	0.890	0.817	0.073	0.918	28	1	0.875	3.663
36	34	N	115	10	R	4	0.942	0.920	0.022	0.976	32	0	1.000	2.316
36	34	N	115	10	R	5	0.932	0.890	0.042	0.955	32	0	1.000	3.253
36	34	N	115	10	R	6	0.912	0.811	0.101	0.889	32	0	1.000	2.796
36	34	N	115	10	R	7	0.982	0.951	0.031	0.969	32	0	1.000	3.501
36	34	N	115	10	R	8	0.918	0.886	0.032	0.965	28	3	0.875	2.626
36	34	N	115	10	R	9	0.896	0.815	0.081	0.909	31	0	0.969	2.468
36	34	N	115	10	R	10	0.980	0.916	0.064	0.935	32	0	1.000	2.050
37	39	M	105	0	T	1	0.943	0.927	0.015	0.984	30	1	0.937	3.000
37	39	M	105	0	T	2	0.893	0.875	0.018	0.980	28	2	0.875	3.111
37	39	M	105	0	T	3	0.368	0.678	-0.310	1.841	28	2	0.875	3.361
37	39	M	105	0	T	4	0.952	0.940	0.012	0.987	30	0	0.937	2.099
37	39	M	105	0	T	5	0.929	0.909	0.020	0.979	31	1	0.969	2.817
37	39	M	105	0	T	6	0.802	0.889	-0.087	1.108	30	0	0.937	2.773
37	39	M	105	0	T	7	0.962	0.946	0.016	0.983	29	0	0.906	2.876
37	39	M	105	0	T	8	0.913	0.905	0.008	0.992	26	3	0.812	2.247
37	39	M	105	0	T	9	0.850	0.802	0.048	0.944	31	0	0.969	2.646
37	39	M	105	0	T	10	0.919	0.924	-0.005	1.006	29	0	0.906	1.995
38	41	F	105	5	W	1	0.946	0.918	0.028	0.971	32	0	1.000	3.094
38	41	F	105	5	W	2	0.857	0.852	0.005	0.994	31	0	0.969	3.327
38	41	F	105	5	W	3	0.795	0.641	0.154	0.806	31	0	0.969	3.063
38	41	F	105	5	W	4	0.936	0.934	0.002	0.998	31	0	0.969	2.206
38	41	F	105	5	W	5	0.920	0.879	0.041	0.955	31	0	0.969	3.045
38	41	F	105	5	W	6	0.894	0.807	0.087	0.902	31	0	0.969	2.800
38	41	F	105	5	W	7	0.976	0.937	0.039	0.960	31	0	0.969	2.916
38	41	F	105	5	W	8	0.910	0.833	0.077	0.915	23	7	0.719	2.692
38	41	F	105	5	W	9	0.886	0.757	0.130	0.854	30	0	0.937	2.587
38	41	F	105	5	W	10	0.952	0.894	0.058	0.939	32	0	1.000	2.126
39	36	M	115	0	T	1	0.964	0.941	0.024	0.976	31	0	0.969	3.229
39	36	M	115	0	T	2	0.922	0.892	0.031	0.967	30	0	0.937	3.095
39	36	M	115	0	T	3	0.887	0.847	0.040	0.955	26	0	0.812	3.304
39	36	M	115	0	T	4	0.938	0.925	0.014	0.986	28	0	0.875	2.094
39	36	M	115	0	T	5	0.934	0.891	0.043	0.954	31	0	0.969	2.577
39	36	M	115	0	T	6	0.938	0.862	0.076	0.919	29	2	0.906	2.507
39	36	M	115	0	T	7	0.984	0.949	0.035	0.964	31	0	0.969	2.835
39	36	M	115	0	T	8	0.962	0.899	0.064	0.934	25	7	0.781	2.336
39	36	M	115	0	T	9	0.901	0.728	0.173	0.808	29	0	0.906	2.393
39	36	M	115	0	T	10	0.936	0.915	0.021	0.977	27	0	0.844	2.147
40	38	F	115	10	W	1	0.960	0.949	0.012	0.988	32	0	1.000	2.914
40	38	F	115	10	W	2	0.901	0.881	0.020	0.978	30	0	0.937	3.034
40	38	F	115	10	W	3	0.787	0.789	-0.002	1.003	26	1	0.812	3.271
40	38	F	115	10	W	4	0.962	0.941	0.021	0.978	31	0	0.969	2.276
40	38	F	115	10	W	5	0.924	0.885	0.040	0.957	31	1	0.969	3.014
40	38	F	115	10	W	6	0.897	0.910	-0.013	1.015	29	0	0.906	2.740
40	38	F	115	10	W.	7	0.972	0.957	0.015	0.984	31	0	0.969	3.137
40	38	F	115	10	W	8	0.956	0.901	0.056	0.942	26	6	0.812	2.621
40	38	F	115	10	W	9	0.586	0.713	-0.126	1.215	31	0	0.969	2.754
40	38	F	115	10	W	10	0.940	0.926	0.014	0.985	26	0	0.812	2.254

RN	RP	V	BKD	SN	PC	SUB	BLINE	PRIM	ACLOS	NORML	CR	NR	ACCY	TIME
41	42	F	105	5	T	1	0.944	0.936	0.008	0.991	31	1	0.969	2.993
41	42	F	105	5	T	2	0.902	0.888	0.015	0.984	28	2	0.875	2.998
41	42	F	105	5	T	3	0.450	0.579	-0.129	1.287	24	3	0.750	3.348
41	42	F	105	5	T	4	0.932	0.919	0.013	0.986	32	0	1.000	1.882
41	42	F	105	5	T	5	0.906	0.871	0.035	0.961	31	1	0.969	2.614
41	42	F	105	5	T	6	0.892	0.907	-0.015	1.016	32	0	1.000	2.389
41	42	F	105	5	T	7	0.970	0.959	0.011	0.989	31	0	0.969	2.785
41	42	F	105	5	T	8	0.906	0.879	0.028	0.970	25	6	0.781	2.632
41	42	F	105	5	T	9	0.699	0.674	0.025	0.964	32	0	1.000	2.515
41	42	F	105	5	T	10	0.924	0.893	0.032	0.966	30	0	0.937	1.908
42	43	N	105	5	T	1	0.926	0.925	0.001	0.999	32	0	1.000	3.003
42	43	N	105	5	T	2	0.909	0.858	0.051	0.944	27	1	0.844	3.054
42	43	N	105	5	T	3	0.217	0.485	-0.268	2.239	27	2	0.844	3.084
42	43	N	105	5	T	4	0.901	0.823	0.078	0.914	32	0	1.000	2.111
42	43	N	105	5	T	5	0.928	0.868	0.061	0.934	31	0	0.969	2.776
42	43	N	105	5	T	6	0.958	0.902	0.057	0.941	31	0	0.969	2.634
42	43	N	105	5	T	7	0.982	0.946	0.036	0.964	31	1	0.969	2.762
42	43	N	105	5	T	8	0.905	0.882	0.022	0.975	25	6	0.781	2.788
42	43	N	105	5	T	9	0.688	0.777	-0.089	1.130	32	0	1.000	2.571
42	43	N	105	5	T	10	0.944	0.914	0.030	0.968	32	0	1.000	2.007
43	44	M	105	5	W	1	0.980	0.935	0.045	0.954	30	1	0.937	3.060
43	44	M	105	5	W	2	0.944	0.850	0.094	0.900	32	0	1.000	2.787
43	44	M	105	5	W	3	0.872	0.784	0.089	0.899	32	0	1.000	3.024
43	44	M	105	5	W	4	0.962	0.919	0.043	0.955	31	0	0.969	2.326
43	44	M	105	5	W	5	0.940	0.857	0.083	0.912	30	0	0.937	2.928
43	44	M	105	5	W	6	0.942	0.880	0.063	0.934	32	0	1.000	2.779
43	44	M	105	5	W	7	0.984	0.964	0.020	0.979	32	0	1.000	3.009
43	44	M	105	5	W	8	0.966	0.910	0.056	0.942	23	7	0.719	2.728
43	44	M	105	5	W	9	0.882	0.805	0.077	0.912	31	0	0.969	2.703
43	44	M	105	5	W	10	0.970	0.942	0.028	0.971	31	0	0.969	2.251
44	45	N	115	10	W	1	0.944	0.943	0.001	0.999	31	0	0.969	3.171
44	45	N	115	10	W	2	0.893	0.868	0.025	0.973	31	1	0.969	2.814
44	45	N	115	10	W	3	0.797	0.814	-0.016	1.021	27	1	0.844	3.431
44	45	N	115	10	W	4	0.940	0.931	0.009	0.990	29	1	0.906	2.491
44	45	N	115	10	W	5	0.932	0.890	0.042	0.955	30	1	0.937	3.070
44	45	N	115	10	W	6	0.926	0.849	0.077	0.916	29	0	0.906	3.100
44	45	N	115	10	W	7	0.984	0.964	0.021	0.979	30	0	0.937	3.209
44	45	N	115	10	W	8	0.841	0.862	-0.021	1.025	22	6	0.687	3.099
44	45	N	115	10	W	9	0.889	0.820	0.068	0.923	30	0	0.937	3.016
44	45	N	115	10	W	10	0.956	0.952	0.004	0.996	30	0	0.937	2.305
45	40	F	115	5	R	1	0.932	0.936	-0.004	1.004	32	0	1.000	3.255
45	40	F	115	5	R	2	0.832	0.857	-0.025	1.030	31	0	0.969	2.993
45	40	F	115	5	R	3	0.273	0.582	-0.309	2.129	21	5	0.656	3.408
45	40	F	115	5	R	4	0.924	0.900	0.025	0.973	28	0	0.875	2.267
45	40	F	115	5	R	5	0.938	0.903	0.035	0.962	31	0	0.969	2.951
45	40	F	115	5	R	6	0.964	0.909	0.055	0.943	31	0	0.969	2.694
45	40	F	115	5	R	7	0.974	0.949	0.025	0.974	32	0	1.000	3.240
45	40	F	115	5	R	8	0.908	0.864	0.044	0.952	23	7	0.719	3.299
45	40	F	115	5	R	9	0.711	0.728	-0.017	1.024	32	0	1.000	2.498
45	40	F	115	5	R	10	0.944	0.934	0.010	0.990	30	0	0.937	2.280

RN	RP	V	BKD	SN	PC	SUB	BLINE	PRIM	ACLOS	NORML	CR	NR	ACCY	TIME
46	48	N	105	10	W	1	0.954	0.937	0.017	0.982	32	0	1.000	3.349
46	48	N	105	10	W	2	0.909	0.868	0.041	0.955	31	1	0.969	3.241
46	48	N	105	10	W	3	0.767	0.536	0.231	0.699	31	0	0.969	3.284
46	48	N	105	10	W	4	0.952	0.905	0.047	0.950	32	0	1.000	2.456
46	48	N	105	10	W	5	0.924	0.886	0.038	0.958	32	0	1.000	2.814
46	48	N	105	10	W	6	0.936	0.841	0.095	0.899	32	0	1.000	2.720
46	48	N	105	10	W	7	0.980	0.938	0.042	0.957	31	0	0.969	3.069
46	48	N	105	10	W	8	0.936	0.864	0.072	0.923	24	7	0.750	3.008
46	48	N	105	10	W	9	0.897	0.763	0.134	0.850	31	0	0.969	2.734
46	48	N	105	10	W	10	0.974	0.932	0.042	0.957	32	0	1.000	2.311
47	46	F	115	10	T	1	0.962	0.940	0.023	0.977	32	0	1.000	2.779
47	46	F	115	10	T	2	0.948	0.902	0.046	0.951	32	0	1.000	2.745
47	46	F	115	10	T	3	0.916	0.872	0.044	0.952	31	0	0.969	2.899
47	46	F	115	10	T	4	0.958	0.936	0.022	0.977	31	1	0.969	2.131
47	46	F	115	10	T	5	0.876	0.804	0.073	0.917	32	0	1.000	2.457
47	46	F	115	10	T	6	0.880	0.851	0.029	0.967	32	0	1.000	2.677
47	46	F	115	10	T	7	0.976	0.944	0.032	0.967	30	0	0.937	3.064
47	46	F	115	10	T	8	0.956	0.915	0.041	0.957	26	6	0.812	2.527
47	46	F	115	10	T	9	0.890	0.820	0.070	0.922	32	0	1.000	2.589
47	46	F	115	10	T	10	0.962	0.940	0.022	0.977	32	0	1.000	2.165
48	47	N	115	0	R	1	0.910	0.936	-0.025	1.028	32	0	1.000	2.908
48	47	N	115	0	R	2	0.896	0.867	0.030	0.967	32	0	1.000	2.777
48	47	N	115	0	R	3	0.878	0.794	0.084	0.904	29	0	0.906	3.246
48	47	N	115	0	R	4	0.954	0.938	0.016	0.983	31	1	0.969	2.138
48	47	N	115	0	R	5	0.912	0.874	0.038	0.959	32	0	1.000	2.980
48	47	N	115	0	R	6	0.890	0.905	-0.015	1.017	32	0	1.000	2.729
48	47	N	115	0	R	7	0.964	0.925	0.039	0.959	30	1	0.937	3.450
48	47	N	115	0	R	8	0.940	0.916	0.024	0.974	24	6	0.750	2.553
48	47	N	115	0	R	9	0.912	0.834	0.079	0.914	31	0	0.969	2.628
48	47	N	115	0	R	10	0.964	0.950	0.014	0.985	32	0	1.000	2.237
49	49	N	105	5	R	1	0.970	0.941	0.029	0.970	32	0	1.000	2.839
49	49	N	105	5	R	2	0.754	0.821	-0.066	1.088	31	0	0.969	3.246
49	49	N	105	5	R	3	0.671	0.609	0.062	0.908	30	0	0.937	3.260
49	49	N	105	5	R	4	0.960	0.916	0.044	0.954	32	0	1.000	2.199
49	49	N	105	5	R	5	0.920	0.851	0.069	0.925	32	0	1.000	3.311
49	49	N	105	5	R	6	0.890	0.878	0.012	0.987	32	0	1.000	2.693
49	49	N	105	5	R	7	0.960	0.942	0.018	0.981	31	0	0.969	3.527
49	49	N	105	5	R	8	0.958	0.907	0.051	0.947	26	6	0.812	2.518
49	49	N	105	5	R	9	0.940	0.795	0.145	0.845	30	0	0.937	2.675
49	49	N	105	5	R	10	0.984	0.910	0.074	0.925	31	0	0.969	2.464
50	50	N	105	5	W	1	0.932	0.930	0.002	0.998	32	0	1.000	3.284
50	50	N	105	5	W	2	0.913	0.835	0.077	0.915	31	1	0.969	3.157
50	50	N	105	5	W	3	0.435	0.581	-0.146	1.335	29	2	0.906	3.207
50	50	N	105	5	W	4	0.952	0.896	0.057	0.940	31	1	0.969	2.560
50	50	N	105	5	W	5	0.920	0.871	0.050	0.946	28	1	0.875	3.227
50	50	N	105	5	W	6	0.911	0.868	0.042	0.953	32	0	1.000	3.150
50	50	N	105	5	W	7	0.952	0.939	0.013	0.986	32	0	1.000	3.145
50	50	N	105	5	W	8	0.950	0.882	0.068	0.928	26	6	0.812	2.767
50	50	N	105	5	W	9	0.891	0.829	0.062	0.930	32	0	1.000	2.698
50	50	N	105	5	W	10	0.938	0.937	0.001	0.999	31	0	0.969	2.333

RN	RP	V	BKD	SN	PC	SUB	BLINE	PRIM	ACLOS	NORML	CR	NR	ACCY	TIME
51	51	M	115	10	W	1	0.958	0.948	0.010	0.990	32	0	1.000	3.159
51	51	M	115	10	W	2	0.858	0.897	-0.039	1.046	32	0	1.000	2.538
51	51	M	115	10	W	3	0.902	0.905	-0.003	1.003	32	0	1.000	3.266
51	51	M	115	10	W	4	0.962	0.931	0.031	0.967	31	0	0.969	2.549
51	51	M	115	10	W	5	0.922	0.875	0.047	0.949	31	1	0.969	2.828
51	51	M	115	10	W	6	0.870	0.858	0.012	0.986	32	0	1.000	3.029
51	51	M	115	10	W	7	0.976	0.973	0.003	0.997	31	0	0.969	2.986
51	51	M	115	10	W	8	0.908	0.886	0.023	0.975	27	3	0.844	2.739
51	51	M	115	10	W	9	0.832	0.811	0.021	0.975	30	0	0.937	2.997
51	51	M	115	10	W	10	0.934	0.933	0.001	0.999	27	0	0.844	2.394
52	52	M	105	5	R	1	0.930	0.938	-0.008	1.008	31	1	0.969	3.441
52	52	M	105	5	R	2	0.889	0.847	0.042	0.953	31	0	0.969	3.011
52	52	M	105	5	R	3	0.875	0.848	0.027	0.970	30	0	0.937	3.597
52	52	M	105	5	R	4	0.954	0.926	0.028	0.971	31	1	0.969	2.135
52	52	M	105	5	R	5	0.922	0.876	0.047	0.950	32	0	1.000	2.959
52	52	M	105	5	R	6	0.861	0.873	-0.012	1.014	32	0	1.000	2.736
52	52	M	105	5	R	7	0.972	0.967	0.005	0.994	32	0	1.000	3.202
52	52	M	105	5	R	8	0.966	0.869	0.098	0.899	26	6	0.812	2.425
52	52	M	105	5	R	9	0.865	0.790	0.075	0.914	32	0	1.000	2.447
52	52	M	105	5	R	10	0.934	0.916	0.019	0.980	32	0	1.000	2.396
53	53	M	105	0	W	1	0.946	0.932	0.014	0.985	31	0	0.969	3.345
53	53	M	105	0	W	2	0.920	0.854	0.066	0.928	30	0	0.937	2.899
53	53	M	105	0	W	3	0.835	0.826	0.009	0.989	29	1	0.906	3.450
53	53	M	105	0	W	4	0.948	0.923	0.025	0.973	29	2	0.906	2.477
53	53	M	105	0	W	5	0.909	0.827	0.082	0.910	29	0	0.906	2.922
53	53	M	105	0	W	6	0.887	0.817	0.069	0.922	29	1	0.906	2.905
53	53	M	105	0	W	7	0.964	0.971	-0.007	1.007	31	0	0.969	2.969
53	53	M	105	0	W	8	0.950	0.908	0.043	0.955	25	4	0.781	2.760
53	53	M	105	0	W	9	0.797	0.727	0.070	0.912	30	0	0.937	2.643
53	53	M	105	0	W	10	0.917	0.914	0.003	0.997	27	0	0.844	2.409
54	54	F	105	0	R	1	0.958	0.928	0.030	0.969	31	0	0.969	3.285
54	54	F	105	0	R	2	0.817	0.858	-0.041	1.050	29	1	0.906	2.645
54	54	F	105	0	R	3	0.833	0.841	-0.008	1.010	29	0	0.906	3.441
54	54	F	105	0	R	4	0.950	0.937	0.013	0.986	29	1	0.906	2.143
54	54	F	105	0	R	5	0.839	0.871	-0.032	1.039	32	0	1.000	2.828
54	54	F	105	0	R	6	0.823	0.885	-0.062	1.075	28	1	0.875	2.507
54	54	F	105	0	R	7	0.970	0.970	0.000	1.000	32	0	1.000	3.184
54	54	F	105	0	R	8	0.877	0.883	-0.006	1.007	26	5	0.812	2.519
54	54	F	105	0	R	9	0.734	0.753	-0.020	1.027	31	0	0.969	2.142
54	54	F	105	0	R	10	0.932	0.935	-0.002	1.003	32	0	1.000	2.221

APPENDIX D3

GROUP PERFORMANCE FILE

(GPFIL)

RN	RP	V	BKD	SN	P	BLINE	PRIM	ACLOS	NORML	MNCORR	NORSP	ACCY	TIME
1	5	N	115	0	W	0.865	0.810	0.054	0.937	25.700	1.600	0.803	2.745
2	6	M	115	10	T	0.855	0.804	0.051	0.940	30.500	0.400	0.953	2.557
3	13	M	105	10	T	0.860	0.833	0.026	0.969	29.800	0.100	0.931	2.537
4	10	F	115	10	R	0.869	0.830	0.039	0.955	30.200	0.100	0.944	2.503
5	9	M	115	5	W	0.857	0.808	0.049	0.942	29.400	0.600	0.919	2.811
6	11	N	105	0	T	0.870	0.791	0.079	0.909	28.100	0.700	0.878	2.682
7	14	F	105	10	W	0.808	0.808	0.000	1.000	30.700	0.200	0.959	2.788
8	1	M	115	0	R	0.849	0.845	0.003	0.996	30.400	0.000	0.950	2.700
9	2	N	115	5	T	0.872	0.839	0.033	0.962	27.500	0.700	0.859	2.762
10	3	N	105	0	W	0.894	0.805	0.090	0.899	29.600	0.900	0.925	2.877
11	15	F	105	10	R	0.834	0.824	0.010	0.988	31.200	0.000	0.975	2.686
12	4	N	115	0	T	0.900	0.870	0.030	0.967	29.100	0.900	0.909	2.816
13	7	M	115	5	T	0.857	0.857	0.000	1.000	29.800	0.600	0.931	2.852
14	16	F	105	5	R	0.856	0.848	0.008	0.991	30.600	0.300	0.956	2.849
15	17	F	105	0	T	0.883	0.861	0.023	0.974	30.600	0.600	0.956	2.666
16	8	M	115	0	W	0.918	0.849	0.070	0.924	30.000	0.300	0.937	2.979
17	12	F	115	5	T	0.905	0.839	0.066	0.927	29.400	0.800	0.919	2.743
18	18	M	105	0	R	0.911	0.846	0.065	0.928	31.200	0.400	0.975	2.958
19	19	N	105	0	R	0.896	0.859	0.037	0.959	31.200	0.500	0.975	3.030
20	20	F	115	0	W	0.936	0.878	0.058	0.938	26.700	0.800	0.834	3.017
21	21	N	105	10	R	0.914	0.865	0.049	0.946	30.800	0.500	0.962	3.144
22	22	F	105	0	W	0.915	0.856	0.059	0.936	30.000	0.400	0.937	2.975
23	24	F	115	5	W	0.836	0.852	-0.016	1.019	28.700	0.800	0.897	2.876
24	23	M	105	5	T	0.903	0.876	0.027	0.970	30.700	0.300	0.959	2.760
25	25	M	115	10	R	0.915	0.850	0.066	0.928	31.300	0.100	0.978	3.020
26	26	N	105	10	T	0.883	0.834	0.050	0.944	29.900	0.500	0.934	2.722
27	27	F	115	0	R	0.909	0.838	0.071	0.922	29.400	0.200	0.919	2.694
28	28	N	115	10	T	0.943	0.885	0.057	0.939	30.300	0.300	0.947	2.721
29	29	N	115	5	R	0.904	0.866	0.038	0.958	30.800	0.300	0.962	2.907
30	32	M	105	10	R	0.893	0.836	0.057	0.936	31.500	0.200	0.984	2.917
31	30	F	115	0	T	0.911	0.880	0.031	0.966	29.700	0.600	0.928	2.712
32	31	M	115	5	R	0.893	0.875	0.017	0.981	31.300	0.500	0.978	2.937
33	35	M	105	10	W	0.869	0.830	0.038	0.956	30.300	0.700	0.947	2.974
34	37	F	105	10	T	0.871	0.826	0.046	0.948	30.300	0.700	0.947	2.667
35	33	N	115	5	W	0.932	0.905	0.027	0.971	29.400	0.700	0.919	2.961
36	34	N	115	10	R	0.930	0.883	0.048	0.949	30.900	0.600	0.966	2.973
37	39	M	105	0	T	0.853	0.880	-0.027	1.031	29.200	0.900	0.913	2.693
38	41	F	105	5	W	0.907	0.845	0.062	0.931	30.300	0.700	0.947	2.788
39	36	M	115	0	T	0.937	0.885	0.052	0.945	28.700	0.900	0.897	2.661
40	38	F	115	10	W	0.889	0.885	0.004	0.996	29.300	0.800	0.916	2.806
41	42	F	105	5	T	0.853	0.850	0.002	0.997	29.600	1.300	0.925	2.583
42	43	N	105	5	T	0.836	0.838	-0.002	1.003	30.000	1.000	0.937	2.663
43	44	M	105	5	W	0.944	0.884	0.060	0.937	30.400	0.800	0.950	2.761
44	45	N	115	10	W	0.910	0.889	0.021	0.977	28.900	1.000	0.903	2.964
45	40	F	115	5	R	0.840	0.856	-0.016	1.019	29.100	1.200	0.909	2.869

RN	RP	V	BKG	SN	P	P-BLA	P-ACC	ACLSS	PRCBL	MNCORR	NORSP	ACC'Y	TIME
46	48	N	105	10	W	0.923	0.847	0.076	0.918	30.800	0.800	0.962	2.893
47	46	F	115	10	T	0.933	0.892	0.040	0.957	31.000	0.700	0.969	2.602
48	47	N	115	0	R	0.922	0.894	0.028	0.969	30.500	0.800	0.953	2.764
49	49	N	105	5	R	0.901	0.857	0.044	0.951	30.700	0.600	0.959	2.877
50	50	N	105	5	W	0.880	0.857	0.023	0.974	30.400	1.100	0.950	2.953
51	51	M	115	10	W	0.912	0.902	0.011	0.988	30.500	0.400	0.953	2.857
52	52	M	105	5	R	0.917	0.885	0.032	0.965	30.900	0.800	0.966	2.838
53	53	M	105	0	W	0.907	0.870	0.037	0.959	29.000	0.800	0.906	2.886
54	54	F	105	0	R	0.873	0.886	-0.013	1.015	29.900	0.800	0.934	2.696

APPENDIX E

ANALYSIS RESULTS

APPENDIX E1

T-TEST RESULTS

------------- T-TEST FOR WITHIN-RUN FATIGUE/LEARNING CURVE -------------

RN	ACC-1	VACC1	ACC-2	VACC2	TIME-1	VTIM1	TIME-2	VTIM2	TACCY	TTIME	TCRIT	CRIT?
==	=====	=====	=====	=====	======	=====	======	=====	=====	=====	=====	**-**
1	0.927	0.036	0.800	0.016	2.760	0.135	2.780	0.144	1.761	0.118	2.101	
2	0.964	0.007	0.955	0.004	2.560	0.147	2.497	0.110	0.278	0.388	2.101	
3	0.955	0.012	0.918	0.006	2.629	0.232	2.454	0.151	0.865	0.894	2.101	
4	0.955	0.005	0.964	0.004	2.568	0.286	2.406	0.171	0.303	0.760	2.101	
5	0.945	0.004	0.973	0.003	2.745	0.166	2.844	0.117	1.029	0.587	2.101	
6	0.900	0.007	0.855	0.005	2.687	0.176	2.718	0.194	1.278	0.162	2.101	
7	0.973	0.003	0.945	0.012	2.761	0.149	2.817	0.181	0.697	0.309	2.101	
8	0.936	0.013	0.982	0.001	2.767	0.138	2.617	0.147	1.188	0.887	2.101	
9	0.945	0.012	0.736	0.024	2.804	0.171	2.726	0.122	3.495	0.455	2.101	A
10	0.973	0.002	0.882	0.007	2.944	0.207	2.788	0.111	3.131	0.876	2.101	A
11	0.982	0.001	0.964	0.007	2.742	0.280	2.618	0.226	0.632	0.553	2.101	
12	0.973	0.007	0.845	0.007	2.733	0.157	2.846	0.260	3.478	0.549	2.101	A
13	0.973	0.003	0.927	0.008	2.841	0.194	2.858	0.167	1.351	0.085	2.101	
14	0.982	0.001	0.964	0.004	2.843	0.235	2.823	0.295	0.816	0.088	2.101	
15	0.973	0.003	0.973	0.003	2.795	0.226	2.532	0.153	0.000	1.352	2.101	
16	0.973	0.003	0.900	0.011	2.880	0.155	3.121	0.270	1.940	1.165	2.101	
17	0.927	0.010	0.909	0.007	2.750	0.205	2.767	0.238	0.452	0.080	2.101	
18	0.964	0.002	0.973	0.003	3.045	0.337	2.937	0.414	0.392	0.393	2.101	
19	0.973	0.003	0.982	0.001	3.092	0.405	2.992	0.339	0.419	0.368	2.101	
20	0.973	0.002	0.845	0.008	2.994	0.241	3.050	0.258	4.008	0.253	2.101	A
21	0.964	0.004	0.955	0.002	3.206	0.394	3.107	0.428	0.381	0.345	2.101	
22	0.945	0.004	0.945	0.004	3.023	0.302	2.941	0.178	0.000	0.376	2.101	
23	0.955	0.004	0.936	0.005	2.871	0.271	2.828	0.192	0.614	0.199	2.101	
24	0.982	0.001	0.927	0.005	2.633	0.138	2.876	0.256	2.236	1.223	2.101	A
25	0.991	0.001	0.982	0.001	2.967	0.310	3.007	0.277	0.632	0.165	2.101	
26	0.964	0.004	0.973	0.003	2.774	0.210	2.595	0.121	0.343	0.981	2.101	
27	0.936	0.008	0.955	0.007	2.696	0.274	2.666	0.208	0.464	0.134	2.101	
28	0.973	0.002	0.936	0.003	2.722	0.177	2.768	0.182	1.606	0.241	2.101	
29	0.982	0.001	0.945	0.007	3.004	0.412	2.896	0.344	1.265	0.395	2.101	
30	0.991	0.001	0.991	0.001	2.900	0.354	2.931	0.340	0.000	0.119	2.101	
31	0.973	0.002	0.873	0.007	2.751	0.184	2.737	0.254	3.395	0.070	2.101	A
32	0.973	0.007	0.964	0.007	2.948	0.307	2.988	0.228	0.246	0.172	2.101	
33	0.945	0.007	0.982	0.003	3.101	0.184	2.910	0.162	1.155	1.024	2.101	
34	0.991	0.001	0.955	0.009	2.740	0.224	2.667	0.219	1.185	0.344	2.101	
35	0.955	0.004	0.891	0.011	2.993	0.145	2.965	0.211	1.645	0.148	2.101	
36	0.982	0.001	0.973	0.002	3.035	0.397	2.983	0.308	0.520	0.195	2.101	
37	0.964	0.007	0.864	0.009	2.754	0.228	2.600	0.171	2.530	0.772	2.101	A
38	0.945	0.004	0.964	0.007	2.799	0.139	2.747	0.124	0.559	0.322	2.101	
39	0.927	0.005	0.864	0.020	2.667	0.197	2.655	0.160	1.276	0.067	2.101	
40	0.918	0.006	0.927	0.013	2.803	0.112	2.759	0.102	0.211	0.305	2.101	
41	0.945	0.004	0.864	0.037	2.629	0.255	2.545	0.201	1.287	0.395	2.101	
42	0.945	0.007	0.909	0.012	2.631	0.122	2.718	0.147	0.845	0.530	2.101	
43	0.955	0.009	0.973	0.003	2.743	0.084	2.831	0.101	0.523	0.647	2.101	

RN	ACC-1	VACC1	ACC-2	VACC2	TIME-1	VTIM1	TIME-2	VTIM2	TACCY	TTIME	TCRIT	CRIT?
==	=====	=====	=====	=====	======	=====	======	=====	=====	=====	=====	**-**
44	0.900	0.014	0.955	0.004	3.014	0.141	2.959	0.109	1.297	0.344	2.101	
45	0.918	0.016	0.882	0.020	2.949	0.154	2.815	0.165	0.610	0.750	2.101	
46	0.964	0.007	0.955	0.004	3.012	0.138	2.836	0.130	0.278	1.073	2.101	
47	0.964	0.004	0.955	0.009	2.594	0.076	2.611	0.084	0.259	0.134	2.101	
48	0.982	0.003	0.945	0.009	2.812	0.141	2.747	0.207	1.069	0.346	2.101	
49	0.982	0.001	0.945	0.007	2.917	0.221	2.838	0.139	1.265	0.420	2.101	
50	0.955	0.007	[illegible]936	0.010	3.042	0.122	2.898	0.134	0.441	0.900	2.101	
51	0.973	0.002	[illegible]36	0.013	2.853	0.056	2.898	0.107	0.938	0.355	2.101	
52	0.955	0.004	0.[illegible]	0.004	2.977	0.223	2.708	0.214	0.335	1.287	2.101	
53	0.973	0.003	0.93[illegible]	0.008	2.936	0.107	2.816	0.132	1.061	0.776	2.101	
54	0.945	0.007	0.964	0.004	2.763	0.275	2.565	0.194	0.559	0.911	2.101	

KEY:

RN:	Run number
ACC-1:	Group mean accuracy for the first one-third responses
VACC1:	Variance for ACC-1
ACC-2:	Group mean accuracy for the last one-third responses
VACC2:	Variance for the ACC-2
TIME-1:	Group mean time for the first one-third correct responses
VTIM1:	Variance for TIME-1
TIME-2:	Group mean time for the last one-third correct responses
VTIM2:	Variance for TIME-2
TACCY:	Student's t-value for accuracy t-test
TTIME:	Student's t-value for response time t-test
TCRIT:	Critical value for "t" using 18 d.f.
CRIT?:	"A" indicates accuracy was statistically significant "T" indicates response time was statistically significant

APPENDIX E2

MANOVA RESULTS

MULTIPLE ANALYSIS OF VARIANCE

TREATMENT	=====HOTELLING'S T=====			======= UNIVARIATE ANOVA =======				--SIGNIF ?--		
				---ACCURACY---		-RESPONSE TIME-				
	T-VALUE	F-VALUE	SIGNIF	F-VALUE	SIGNIF	F-VALUE	SIGNIF	HOT	ACCY	TIME
VOICE TYPE [VTYPE]	.07322	8.73148	6.4E-7	6.1737	0.002	11.2024	1.8E-5	YES	YES	YES
BACKGROUND [BKGRD]	.02784	6.65354	0.001	13.1604	0.0003	0.0652	0.799	YES	YES	No
SIG/NOISE [SNRAT]	.06428	7.66580	4.4E-6	14.5739	7.2E-7	0.5678	0.567	YES	YES	No
PRECURSOR [PREC]	.21211	25.29370	0.000	24.6654	0.000	26.1132	0.000	YES	YES	YES
SUBJECT NO.	4.3148	114.34263	0.000	37.3532	0.000	189.5643	0.000	YES	YES	YES
VTYPE X BKGRD	.02308	2.75176	0.027	5.1847	0.006	0.3994	0.671	YES	YES	No
VTYPE X SNRAT	.02850	1.69954	0.094	0.6057	0.659	2.7268	0.029	No	No	(YES)
VTYPE X PREC	.04802	2.86307	0.004	1.5073	0.199	4.4369	0.002	YES	No	YES
BKGRD X SNRAT	.01753	2.09065	0.080	0.8322	0.436	3.4400	0.033	No	No	(YES)
BKGRD X PREC	.03193	3.80768	0.004	3.9409	0.020	3.6643	0.026	YES	YES	YES
SNRAT X PREC	.03951	2.35561	0.016	1.4881	0.205	3.0836	0.016	YES	No	YES
VTYPE X BKGRD X SNRAT	.01065	0.63495	0.749	0.3622	0.836	0.9000	0.464	No	No	No
VTYPE X BKGRD X PREC	.03351	1.99817	0.044	3.1392	0.014	0.8467	0.496	YES	YES	No
VTYPE X SNRAT X PREC	.09713	2.89571	0.0001	1.9641	0.049	3.9315	1.6E-4	YES	YES	YES
VTYPE X BKGRD X SNRAT X PREC	.07106	2.11843	0.006	2.9185	0.003	1.4467	0.175	YES	YES	No

APPENDIX E3

UNIVARIATE ANOVA RESULTS

UNIVARIATE ANALYSIS OF VARIANCE
Using Unadjusted Response Times

------- UNIVARIATE SIGNIFICANCE FOR DISCRIMINATION -------

	----ACCURACY----		--RESPONSE TIME--		
TREATMENT	F Value	Signif of F	F Value	Signif of F	Signif ?
VOICE TYPE	8.506	0.000	43.767	0.000	ACCY TIME
BACKGROUND	35.322	0.000	0.131	0.717	ACCY
S/N RATIO	26.533	0.000	2.205	0.111	ACCY
PRECURSOR	38.674	0.000	152.937	0.000	ACCY TIME
SUBJECT SEX	101.573	0.000	82.172	0.000	ACCY TIME

GROUPING BY SHEFFE PROCEDURE
(Unadjusted Response Times)

VOICE TYPE

ACCURACY	Mean	RESPONSE TIME	Mean
Subset 1		Subset 1	
MALE	.9460	FEMALE	2.7486
Subset 2		Subset 2	
FEMALE	.9318	MALE	2.8182
MACHINE	.9281	Subset 3	
		MACHINE	2.8612

BACKGROUND

ACCURACY	Mean	RESPONSE TIME	Mean
Subset 1		Subset 1	
105 db	.9464	115 db	2.8075
SUBSET 2		105 db	2.8111
115 db	.9242		

S/N RATIO

ACCURACY	Mean	RESPONSE TIME	Mean
Subset 1		Subset 1	
10 db	.9517	10 db	2.7969
Subset 2		0 db	2.8091
5 db	.9358	5 db	2.8222
Subset 3			
0 db	.9184		

PRECURSOR

ACCURACY	Mean	RESPONSE TIME	Mean
Subset 1		Subset 1	
REPEATED	.9582	TONE	2.6882
Subset 2		Subset 2	
TONE	.9274	REPEATED	2.8549
VOICE	.9203	VOICE	2.8839

APPENDIX E4

ANOVA RESULTS
BY SUBJECT SEX

UNIVARIATE ANALYSIS OF VARIANCE
BY SUBJECT SEX
(Unadjusted Response Times)

------- UNIVARIATE SIGNIFICANCE FOR DISCRIMINATION -------

	----ACCURACY----		--RESPONSE TIME--		
TREATMENT	F Value	Signif of F	F Value	Signif of F	Signif ?
SUBJECT SEX	101.573	0.000	82.172	0.000	ACCY TIME
MEN: VOICE TYPE	1.641	0.194	7.273	0.001	TIME
WOMEN: VOICE TYPE	6.987	0.001	45.388	0.000	ACCY TIME

------------GROUPING BY SHEFFE PROCEDURE-----------
(Unadjusted Response Times)

----- SUBJECT SEX -----

------- ACCURACY --------	Mean	-----RESPONSE TIME -------	Mean
Subset 1		Subset 1	
MEN	.9583	WOMEN	2.7719
Subset 2		Subset 2	
WOMEN	.9199	MEN	2.8631

----- MALE SUBJECTS -----

------- ACCURACY --------	Mean	-----RESPONSE TIME -------	Mean
Subset 1		Subset 1	
MALE VOICE	.9644	FEMALE VOICE	2.8269
FEMALE VOICE	.9562	MALE VOICE	2.8579
MACHINE VOICE	.9544	Subset 2	
		MALE VOICE	2.8579
		MACHINE VOICE	2.9047

----- FEMALE SUBJECTS -----

------- ACCURACY --------	Mean	-----RESPONSE TIME -------	Mean
Subset 1		Subset 1	
MALE VOICE	.9337	FEMALE VOICE	2.6941
Subset 2		Subset 2	
FEMALE VOICE	.9155	MALE VOICE	2.7908
MACHINE VOICE	.9106	Subset 3	
		MACHINE VOICE	2.8309

APPENDIX E5

ANOVA RESULTS:

ADJUSTED RESPONSE TIMES

UNIVARIATE ANALYSIS OF VARIANCE

** Response Times Adjusted for Warning Length **

------- UNIVARIATE SIGNIFICANCE FOR DISCRIMINATION -------

	----ACCURACY----		--RESPONSE TIME--		
TREATMENT	F Value	Signif of F	F Value	Signif of F	Signif ?
VOICE TYPE	8.506	0.000	18.511	0.000	ACCY TIME
BACKGROUND	35.322	0.000	0.184	0.668	ACCY
S/N RATIO	26.533	0.000	1.609	0.201	ACCY
PRECURSOR	38.674	0.000	1763.836	0.000	ACCY TIME
SUBJECT SEX	101.573	0.000	73.865	0.000	ACCY TIME
MEN: VOICE TYPE	1.641	0.194	13.657	0.000	TIME
WOMEN: VOICE TYPE	6.987	0.001	7.064	0.001	ACCY TIME

------------GROUPING BY SHEFFE PROCEDURE-----------
(Adjusted Response Times)

----- VOICE TYPE -----

------- ACCURACY --------	Mean	-----RESPONSE TIME -------	Mean
Subset 1		Subset 1	
MALE	.9460	MALE	1.0350
Subset 2		Subset 2	
FEMALE	.9318	MACHINE	1.0952
MACHINE	.9281	FEMALE	1.1110

----- BACKGROUND -----

------- ACCURACY --------	Mean	-----RESPONSE TIME -------	Mean
Subset 1		Subset 1	
105 db	.9464	115 db	1.0778
SUBSET 2		105 db	1.0824
115 db	.9242		

----- S/N RATIO -----

------- ACCURACY --------	Mean	-----RESPONSE TIME -------	Mean
Subset 1		Subset 1	
10 db	.9517	10 db	1.0695
Subset 2		0 db	1.0781
5 db	.9358	5 db	1.0929
Subset 3			
0 db	.9184		

----- PRECURSOR -----

------- ACCURACY --------	Mean	-----RESPONSE TIME -------	Mean
Subset 1		Subset 1	
REPEATED	.9582	REPEATED	.6770
Subset 2		Subset 2	
TONE	.9274	VOICE	1.2648
VOICE	.9203	Subset 3	
		TONE	1.3133

----- SUBJECT SEX -----

------- ACCURACY --------	Mean	-----RESPONSE TIME -------	Mean
Subset 1		Subset 1	
MEN	.9583	WOMEN	1.0415
Subset 2		Subset 2	
WOMEN	.9199	MEN	1.1358

----- MALE SUBJECTS -----

------- ACCURACY --------	Mean	-----RESPONSE TIME -------	Mean
Subset 1		Subset 1	
MALE VOICE	.9644	MALE VOICE	1.0763
FEMALE VOICE	.9562	Subset 2	
MACHINE VOICE	.9544	MACHINE VOICE	1.1416
		FEMALE VOICE	1.1899

----- FEMALE SUBJECTS -----

------- ACCURACY --------	Mean	-----RESPONSE TIME -------	Mean
Subset 1		Subset 1	
MALE VOICE	.9337	MALE VOICE	1.0065
Subset 2		Subset 2	
FEMALE VOICE	.9155	FEMALE VOICE	1.0560
MACHINE VOICE	.9106	MACHINE VOICE	1.0628

APPENDIX F

SUBJECT QUESTIONNAIRE

Voice-Warning

QUESTIONNAIRE

Thank you for participating in our experiment to help determine response accuracy and speed to different voice types. As we explained at the beginning, results from this experiment will be useful for designing better alerting systems for our crewmembers, thereby improving aircraft safety and survivability.

No experiment dealing with human reaction is really complete unless the personal reaction of the subjects is also taken into account. To help us in our evaluation, we would appreciate it if you would please complete the following questionnaire as completely as possible.

Please circle the answer which most appropriately reflects your feelings and reactions. If none of the answers seems appropriate for you, please mark "other" and explain.

Some of the answers will request a "scale" of your reaction, rather than a direct answer. In marking your answers for those type questions, please use the following scale:

(a) Not at all,	completely disagree,	extremely negative,	etc.
(b) A little,	mildly disagree,	slightly negative,	etc.
(c) Neutral,	middle-of-the-road,	ambivalent,	etc.
(d) Somewhat,	mildly agree,	mildly positive,	etc.
(e) Very much,	strongly agree,	extremely positive,	etc.

(f) Other (please explain)

NAME (Optional) ______________________________

Seat/Module Number ___________

1. The primary (tracking) task kept me occupied throughout each session.

(a) (b) 1 (c) (d) (e) 9 (f) ___________

2. There was adequate time to respond to the primary task.

(a) (b) 1 (c) 2 (d) 6 (e) 1 (f) ___________

3. I knew exactly when a particular session should end, either through timing or by counting the number of warnings.

(a) 2 (b) 2 (c) (d) 6 (e) (f) ___________

4. I could anticipate which "warning" button would be called for next.

(a) 6 (b) 1 (c) (d) 2 (e) 1 (f) ___________

5. I could anticipate when the next "warning" would be called for.

(a) 4 (b) 4 (c) (d) 2 (e) (f) ___________

6. When required to respond to the "warning", I completely ignored the primary task (tracking) until after I had responded to the warning.

(a) 2 (b) 1 (c) 1 (d) 6 (e) (f) ___________

7. To which voice type did you feel most comfortable responding?

(a) Male 6 (b) Female 4 (c) Machine

8. To which voice do you *think* you responded most accurately?

(a) Male 6 (b) Female 4 (c) Machine

9. To which voice do you *think* you responded most quickly?

(a) Male 4 (b) Female 6 (c) Machine

10. Which voice did you prefer?

(a) Male 4 (b) Female 6 (c) Machine

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